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PALEY # NATURAL THEOLOGY

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NATURAL THEOLOGY;

OR

EVIDENCES

OF THE

EXISTENCE AND ATTRIBUTES

OF

THE DEITY,

COLLECTED FROM THE APPEARANCES OF NATURE.

BY WILLIAM PALEY, D.D.

ILLUSTRATED BY A

SERIES OF PLATES, AND EXPLANATORY NOTES,

BY JAMES PAXTON,

MEMBER OF THE ROYAL COLLEGE OF SURGEONS, LONDON.

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NATURAL THEOLOGY.

CHAPTER XIII.

PECULIAR ORGANIZATIONS.

I BELIEVE that all the instances which I shall collect under this title, might, consistently enough with technical language, have been placed under the head of *Comparative Anatomy*. But there appears to me an impropriety in the use which that term hath obtained: it being, in some sort, absurd to call that a case of comparative anatomy, in which there is nothing to "compare;" in which a conformation is found in one animal, which hath nothing properly answering to it in another. Of this kind are the examples which I have to propose in the present chapter: and the reader will see that, though some of them be the strongest, perhaps, he will meet with under any division of our subject, they must necessarily be of an unconnected and miscellaneous nature. To dispose them, however, into some sort of order, we will notice first, particularities of structure which be-

long to quadrupeds, birds, and fish, as such, or to many of the kinds included in these classes of animals ; and then, such particularities as are confined to one or two species.

I. Along each side of the neck of large *quadrupeds*, runs a stiff, robust ligament, which butchers call the pax-wax. No person can carve the upper end of a crop of beef without driving his knife against it. It is a tough, strong, tendinous substance, braced from the head to the middle of the back: its office is to assist in supporting the weight of the head. It is a mechanical provision, of which this is the undisputed use; and it is sufficient, and not more than sufficient, for the purpose which it has to execute. The head of an ox or a horse is a heavy weight, acting at the end of a long lever, (consequently with a great purchase,) and in a direction nearly perpendicular to the joints of the supporting neck. From such a force, so advantageously applied, the bones of the neck would be in constant danger of dislocation, if they were not fortified by this strong tape.* No such organ is

* We cannot view this proof of the Divine power as manifest in the structure of the neck of animals without admiration at the contrivance by which muscular power is compensated for, by this ligament (*ligamentum nuchæ*). Muscular power must be relieved, it cannot always be kept in action ; therefore in animals, particularly those which have long necks, as the camel, giraffe, &c. and in birds, as the ostrich, crane, swan, &c. we find a very powerful ligamentum nuchæ, so that, by means of this strong elastic substance, the head is supported without muscular exertion.

found in the human subject,* because, from the erect position of the head, (the pressure of it acting nearly in the direction of the spine,) the junction of the vertebræ appears to be sufficiently secure without it. This cautionary expedient, therefore, is limited to quadrupeds: the care of the Creator is seen where it is wanted.

II. The *oil* with which *birds* prune their feathers, and the organ which supplies it, is a specific provision for the winged creation. On each side of the rump of birds is observed a small nipple, yielding upon pressure a butter-like substance, which the bird extracts by pinching the pap with its bill. With this oil, or ointment, thus procured, the bird dresses its coat; and repeats the action as often as its own sensations teach it that it is in any part wanted, or as the excretion may be sufficient for the expense.† The gland, the pap, the nature and quality of the excreted substance, the manner of obtaining it from its lodgment in the body, the application of it when obtained, form, collectively, an evidence of intention which it is

* There is a slight trace of it in man, but it is comparatively small.

† There are glands in the skin of birds for the secretion of oil, as being important for the support of the feathers. Beside these each feather appears to be supplied with oily matter from the point of the skin where it is inserted. But the quantity of oil necessary for rendering them impenetrable to water is furnished by the oil glands here mentioned, situated on the sacrum, which are particularly large in wading and aquatic birds, and they pour out their oil by two fissure-like openings.

not easy to withstand. Nothing similar to it is found in unfeathered animals. What blind *conatus* of nature should produce it in birds? should not produce it in beasts?

III. The *air-bladder* also of a *fish* affords a plain and direct instance, not only of contrivance but strictly of that species of contrivance which we denominate mechanical. It is a philosophical apparatus in the body of an animal. The principle of the contrivance is clear; the application of the principle is also clear. The use of the organ to sustain, and, at will, also to elevate the body of the fish in the water, is proved by observing, what has been tried, that when the bladder is burst, the fish grovels at the bottom: and also, that flounders, soles, skates, which are without the air-bladder, seldom rise in the water, and that with effort.* The manner in which the purpose is attained, and the suitableness of the means to the end, are not difficult to be apprehended. The rising and sinking of a fish in water, so far as it is independent of the stroke of the fins and tail, can only be regulated by the specific gravity of the body. When the bladder contained in the body of the fish is

* Tab. XXIII. Fig. 3. The *air-bladder* in the roach. This vessel differs in size and shape, in different species of fish; generally communicating, by one or more ducts, either with the œsophagus or stomach; by which means the fish receives or expels the air, thus sinking or rising without effort: but as some are destitute of this organ, it is considered as an accessary instrument of motion: such fish live almost uniformly at the bottom of the water.

contracted, which the fish probably possesses a muscular power of doing, the bulk of the fish is contracted along with it; whereby, since the absolute weight remains the same, the specific gravity, which is the sinking force, is increased, and the fish descends; on the contrary, when, in consequence of the relaxation of the muscles, the elasticity of the enclosed and now compressed air restores the dimensions of the bladder, the tendency downwards becomes proportionably less than it was before, or is turned into a contrary tendency. These are known properties of bodies immersed in a fluid. The enamelled figures, or little glass bubbles, in a jar of water, are made to rise and fall by the same artifice. A diving machine might be made to ascend and descend, upon the like principle; namely, by introducing into the inside of it an air-vessel, which by its contraction would diminish, and by its distension enlarge, the bulk of the machine itself, and thus render it specifically heavier, or specifically lighter, than the water which surrounds it. Suppose this to be done, and the artist to solicit a patent for his invention: the inspectors of the model, whatever they might think of the use or value of the contrivance, could by no possibility entertain a question in their minds, whether it were a contrivance or not. No reason has ever been assigned—no reason can be assigned, why the conclusion is not as certain in the fish as it is in the

machine ; why the argument is not as firm in one case as the other.

It would be very worthy of inquiry, if it were possible to discover, by what method an animal, which lives constantly in water, is able to supply a repository of air. The expedient, whatever it be, forms part, and perhaps the most curious part, of the provision. Nothing similar to the air-bladder is found in land-animals ; and a life in the water has no natural tendency to produce a bag of air. Nothing can be farther from an acquired organization than this is.

These examples mark the attention of the Creator to the three great kingdoms of his animal creation, and to their constitution as such.—The example which stands next in point of generality, belonging to a large tribe of animals, or rather to various species of that tribe, is the poisonous tooth of serpents.

I. The *fang of a viper** is a clear and curious example of mechanical contrivance. It is a perforated tooth, loose at the root : in its quiet state,

* Fig. 4. The head of a viper of the natural size. Fig. 5. the *fang* magnified, at the root of which is the gland which secretes the venom : a hair is represented in the tube, through which the poison is ejected. "As these sharp teeth are very liable to accidents, others are ready to supply their places when wanted : for such purpose there is commonly provided two or three half grown fangs, which are connected only by soft parts with the jaw, and are successively moved forwards into the socket to replace those that were lost." See Sir E. Home, Lectures &c. vol. i. p. 333.

lying down flat upon the jaw, but furnished with a muscle, which with a jerk, and by the pluck as it were of a string, suddenly erects it. Under the tooth, close to its root, and communicating with the perforation, lies a small bag containing the venom. When the fang is raised, the closing of the jaw presses its root against the bag underneath, and the force of this compression sends out the fluid with a considerable impetus through the tube in the middle of the tooth. What more unequivocal, or effectual apparatus could be devised, for the double purpose of at once inflicting the wound and injecting the poison? Yet, though lodged in the mouth, it is so constituted, as, in its inoffensive and quiescent state, not to interfere with the animal's ordinary office of receiving its food. It has been observed also, that none of the harmless serpents, the black snake, the blind worm, &c. have these fangs, but teeth of an equal size; not moveable, as this is, but fixed into the jaw.

II. In being the property of several different species, the preceding example is resembled by that which I shall next mention, which is the *bag of the opossum*. This is a mechanical contrivance, most properly so called. The simplicity of the expedient renders the contrivance more obvious than many others, and by no means less certain. A false skin under the belly of the animal forms a pouch, into which the young litter are received at

their birth; where they have an easy and constant access to the teats; in which they are transported by the dam from place to place; where they are at liberty to run in and out; and where they find a refuge from surprise and danger. It is their cradle, their asylum, and the machine for their conveyance.* Can the use of this structure be doubted of. Nor is it a mere doubling of the skin; but it is a new organ, furnished with bones and muscles of its own. Two bones are placed before the os pubis, and joined to that bone as their base.† These support, and give a fixture to, the muscles which serve to open the bag. To these muscles there are antagonists, which serve in the same manner to shut it; and this office they perform so exactly, that, in the living animal, the opening can scarcely be discerned, except when the sides are forcibly drawn asunder. Is there any action in this part of the animal, any process arising from

* Tab. XXIV. Fig. 1. The American opossum; (*didelphis virginiana*). The body of the animal is of a greyish yellow colour, some hairs entirely black, with others entirely white; the tail furnished with scales; the hands, nose, and ears naked.

The female has the whole length of the belly cleft or slit, and appears like a person's waistcoat buttoned only at the top and bottom. This cavity the animal has the power of firmly closing. Within are thirteen teats, extremely small, one in the centre, and the rest ranged round it. See Animal Kingdom, vol. iii. p. 29. Fig. 2. one of the young of the oppossum.

† Fig. 3. The pelvis of the opossum; *a*, *a*, the two bones (*ossa marsupialia*) placed on the anterior part called the *ossa pubis*.

TAB. XXIV

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TAB. XXV

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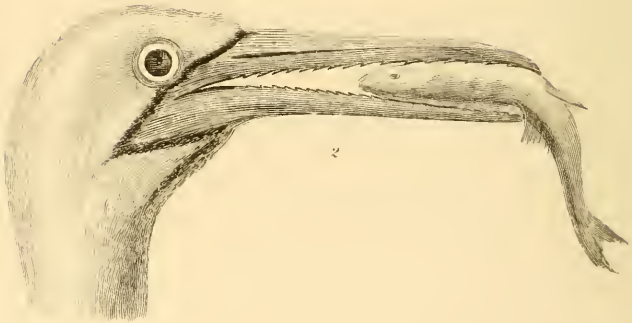

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that action, by which these members could be formed? any account to be given of the formation, except design?

III. As a particularity, yet appertaining to more species than one, and also as strictly mechanical, we may notice a circumstance in the structure of the *claws* of certain birds. The middle claw of the heron and cormorant is toothed and notched like a saw.* These birds are great fishers, and these notches assist them in holding their slippery prey. The use is evident; but the structure such as cannot at all be accounted for by the effort of the animal, or the exercise of the part. Some other fishing birds have these notches in their *bills;* and for the same purpose. The gannet, or Soland goose, has the edges of its bill irregularly jagged, that it may hold its prey the faster.† Nor can the structure in this, more than in the former case, arise from the manner of employing the part. The smooth surfaces, and soft flesh of fish, were less likely to notch the bills of birds, than the hard bodies upon which many other species feed.

We now come to particularities strictly so called,

* Tab. XXV. Fig. 1. *The middle claw of the heron.* A bird so well known as to require no description.

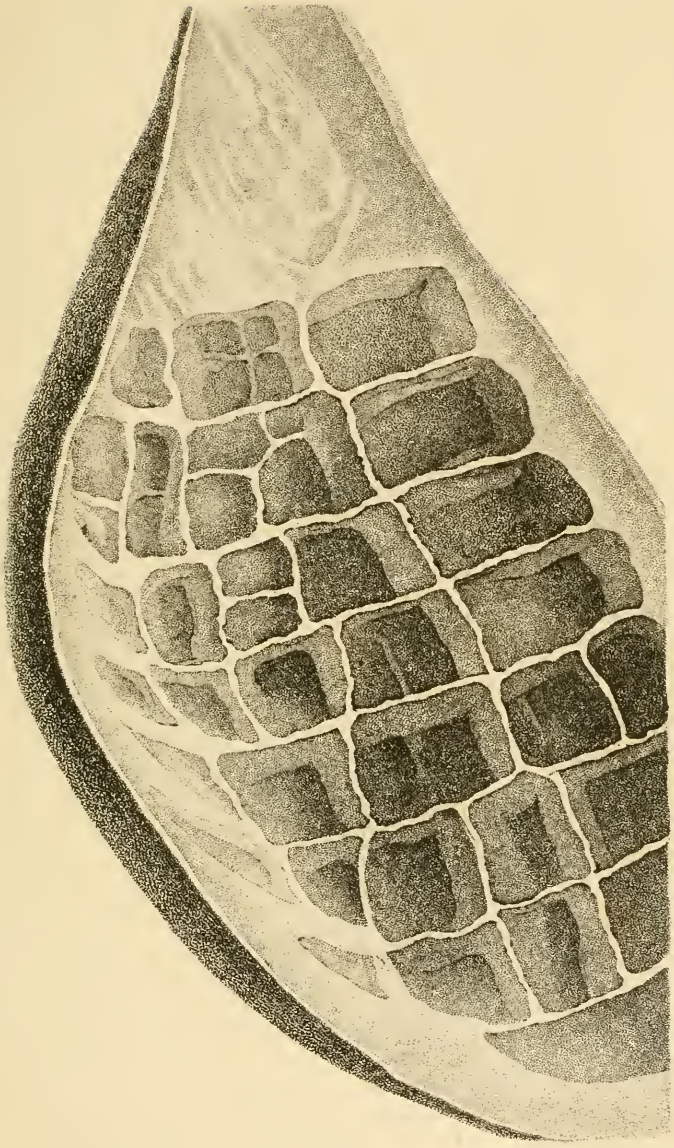
† Fig. 2. The head of the *Soland goose*, (pelicanus bassanus) drawn from a specimen in the Ashmolean Museum. This bird inhabits the coldest parts of this kingdom, more especially the Northern Isles of Scotland. The inhabitants of St. Kilda make it their principal article of food, and are said to consume annually near 30,000 young birds, beside an amazing quantity of eggs.

as being limited to a single species of animal. Of these I shall take one from a quadruped and one from a bird.

I. the *stomach of the camel* is well known to retain large quantities of water, and to retain it unchanged for a considerable length of time.* This property qualifies it for living in the desert. Let us see, therefore, what is the internal organization, upon which a faculty so rare, and so beneficial, depends. A number of distinct sacks or bags (in a dromedary thirty of these have been counted) are observed to lie between the membranes of the second stomach, and to open into the stomach near the top by small square apertures. Through these orifices, after the stomach is full, the annexed bags are filled from it; and the water so deposited is, in the first place, not liable to pass into

* Tab. XXVI. exhibits the *cells in the stomach of the camel*, from a preparation in the museum of the Royal College of Surgeons, London. In the camel, dromedary, and lama, there are four stomachs, as in horned ruminants; but the structure, in some respects, differs from those of the latter. The camel tribe have in the first and second stomach numerous cells, several inches deep, formed by bands of muscular fibres crossing each other at right angles; these are constructed so as to retain the water, and completely exclude the food. In a camel dissected by Sir E. Home, the cells of the stomach were found to contain two gallons of water; but, in consequence of the muscular contraction which had taken place immediately after death, he was led to conclude this was a quantity much less than these cavities were capable of receiving in the living animal. See Lectures on Comparative Anatomy, by Sir E Home, vol. i. p. 168. Mr. Bruce states in his travels that he procured four gallons of water from a camel, which, from necessity, he slaughtered in Upper Egypt. Shaw's Abridgment of Bruce's Travels, edit. iii. p. 371.

TAB. XXVI



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the intestines; in the second place, is kept separate from the solid aliment; and, in the third place, is out of the reach of the digestive action of the stomach, or of mixture with the gastric juice. It appears probable, or rather certain, that the animal, by the conformation of its muscles, possesses the power of squeezing back this water from the adjacent bags into the stomach, whenever thirst excites it to put this power in action.*

II. The *tongue of the woodpecker* is one of those singularities which nature presents us with when a singular purpose is to be answered. It is a particular instrument for a particular use: and what, except design, ever produces such? The woodpecker lives chiefly upon insects, lodged in the bodies of decayed or decaying trees. For the purpose of boring into the wood, it is furnished with a bill, straight, hard, angular, and sharp.† When, by means of this piercer, it has reached the cells of the insects, then comes the office of its tongue; which tongue is, first, of such a length that the bird can dart it out three or four inches from the bill,—in this respect differing greatly from every other species of bird; in the second place, it is tipped with a stiff, sharp, bony thorn; and in the third place, (which appears to me the most remarkable property of all,) this tip is dentated on

* The stomach of the lama has the same power.

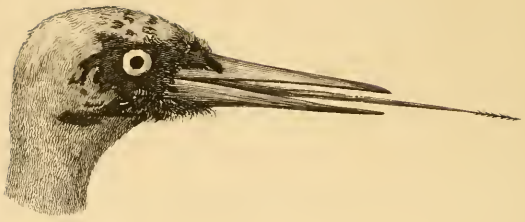
† Tab. XXVII. Fig. 1. The *head of the woodpecker*, (picus viridis.)

both sides, like the beard of an arrow or the barb of a hook.* The description of the part declares its uses. The bird having exposed the retreats of the insects by the assistance of its bill, with a motion inconceivably quick, launches out at them this long tongue, transfixes them upon the barbed needle at the end of it, and thus draws its prey within its mouth.† If this be not mechanism, what is? Should it be said, that, by continual endeavours to shoot out the tongue to the stretch, the woodpecker's species may by degrees have lengthened the organ itself beyond that of other birds, what account can be given of its form, of its tip? how, in particular, did it get its barb, its dentation? These barbs, in my opinion, wherever they occur, are decisive proofs of mechanical contrivance.

III. I shall add one more example, for the sake of its novelty. It is always an agreeable discovery, when, having remarked in an animal an extraordinary structure, we come at length to find out an unexpected use for it. The following narrative furnishes an instance of this kind. The babyrouessa, or Indian hog, a species of wild boar, found in the

* Fig. 2. The *tongue*, the natural size.

† This is accomplished by a most curious piece of mechanism, thus; two curved cartilages, nearly as elastic as steel springs, pass from the bone which supports the tongue to the back of the neck and round the head: a muscle is attached to the inner curvature of each cartilage, and their combined action projects the tongue to a considerable distance. The elasticity of the cartilages retracts the tongue into the mouth. Dr. Roget, vol. 2. p. 132.



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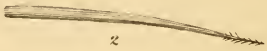

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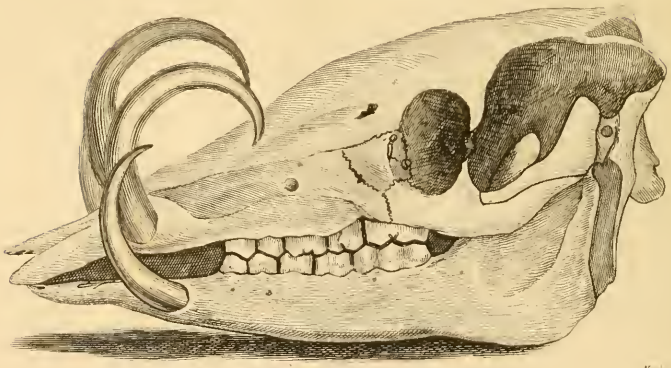

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East Indies, has two *bent* teeth, more than half a yard long, growing upwards, and (which is the singularity) from the upper jaw. These instruments are not wanted for offence; that service being provided for by two tusks issuing from the upper jaw, and resembling those of the common boar; nor does the animal use them for defence. They might seem therefore to be both a superfluity and an encumbrance. But observe the event:—the animal sleeps standing; and, in order to support its head, hooks its upper tusks upon the branches of trees.*

CHAPTER XIV.

PROSPECTIVE CONTRIVANCES.

I can hardly imagine to myself a more distinguishing mark, and consequently a more certain proof of design, than *preparation*, *i. e.* the providing

* Tab. XXVII. Fig. 4. The *skull of the babyrouessa*, from a specimen in the Anatomy School, Christ Church, Oxford. This animal is nearly the size of the common hog, and instead of bristles, is covered with fine short and woolly hair, of a deep brown or black colour. It is also distinguished by the extraordinary position and form of the *upper tusks*, which are not situated on the edge of the jaw, as in other animals, but are placed externally, perforating the skin of the snout, and turning upwards towards the forehead.

The babyrouessa is found in large herds in many parts of Java, Amboina, and other Indian islands, and feeds on vegetables.

of things beforehand which are not to be used until a considerable time afterwards: for this implies a contemplation of the future, which belongs only to intelligence.

Of these *prospective* contrivances, the bodies of animals furnish various examples.

I. The human teeth afford an instance, not only of prospective contrivance, but of the completion of the contrivance being designedly suspended. They are formed within the gums, and there they stop; the fact being, that their farther advance to maturity would not only be useless to the new-born animal, but extremely in its way; as it is evident that the act of *sucking*, by which it is for some time to be nourished, will be performed with more ease both to the nurse and to the infant, whilst the inside of the mouth, and edges of the gums, are smooth and soft, than if set with hard pointed bones. By the time they are wanted, the teeth are ready. They have been lodged within the gums for some months past, but detained as it were in their sockets, so long as their further protrusion would interfere with the office to which the mouth is destined.* Nature, namely, that intelligence which was employed in creation, looked beyond the first year of the infant's life; yet, whilst she was providing for functions which were

* Tab. XXVIII. Fig. 1. The gums and outer plate of the bone are removed, shewing the teeth of the infant as they exist at the time of its birth; they are without roots, and contained in a capsule within the jaws.

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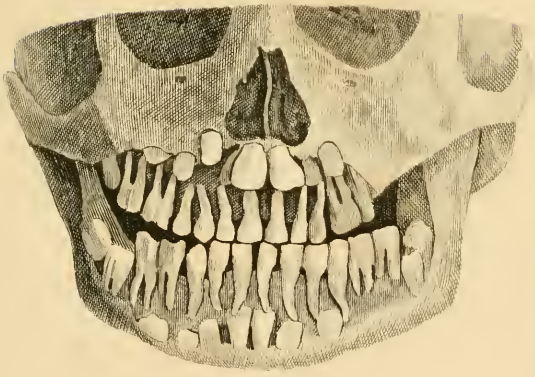

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after that term to become necessary, was careful not to incommode those which preceded them. What renders it more probable that this is the effect of design, is, that the teeth are imperfect, whilst all other parts of the mouth are perfect. The lips are perfect, the tongue is perfect; the jaws, the palate, the pharynx, the larynx, are all perfect: the teeth alone are not so. This is the fact with respect to the human mouth: the fact also is, that the parts above enumerated are called into use from the beginning; whereas the teeth would be only so many obstacles and annoyances, if they were there. When a contrary order is necessary, a contrary order prevails. In the worm of the beetle, as hatched from the egg, the teeth are the first things which arrive at perfection. The insect begins to gnaw as soon as it escapes from the shell, though its other parts be only gradually advancing to their maturity.

What has been observed of the teeth, is true of the *horns* of animals, and for the same reason. The horn of a calf or lamb does not bud, or at least does not sprout to any considerable length, until the animal be capable of browsing upon its pasture; because such a substance upon the forehead of the young animal, would very much incommode the teat of the dam in the office of giving suck.

But in the case of the *teeth*, of the human teeth at least, the prospective contrivance looks still

farther. A succession of crops is provided, and provided from the beginning; a second tier being originally formed beneath the first, which do not come into use till several years afterwards. And this double or suppletory provision meets a difficulty in the mechanism of the mouth, which would have appeared almost insurmountable. The expansion of the jaw (the consequence of the proportionable growth of the animal, and of its skull,) necessarily separates the teeth of the first set, however compactly disposed to a distance from one another, which would be very inconvenient. In due time, therefore, *i. e.* when the jaw has attained a great part of its dimensions, a new set of teeth springs up (loosening and pushing out the old ones before them,) more exactly fitted to the space which they are to occupy, and rising also in such close ranks, as to allow for any extension of line which the subsequent enlargement of the head may occasion.*

II. It is not very easy to conceive a more evidently prospective contrivance than that which, in all viviparous animals, is found in the *milk* of the female parent. At the moment the young animal enters the world, there is its maintenance ready for

* Fig. 2. In this figure also, the outer alveolar plate of the jaw has been removed to shew the succession of teeth. This is the state at six years of age. The *temporary* teeth are all shed between the ages of seven and fourteen, and are supplied by the *permanent teeth*, already nearly perfectly formed, and situated at the roots of the former.

it. The particulars to be remarked in this economy are neither few nor slight. We have, first, the nutritious quality of the fluid, unlike, in this respect every other excretion of the body; and in which nature hitherto remains unimitated, neither cookery nor chemistry having been able to make milk out of grass; we have secondly, the organ for its reception and retention; we have, thirdly, the excretory duct annexed to that organ; and we have, lastly, the determination of the milk to the breast, at the particular juncture when it is about to be wanted. We have all these properties in the subject before us; and they are all indications of design. The last circumstance is the strongest of any. If I had been to guess beforehand, I should have conjectured that at the time when there was an extraordinary demand for nourishment in one part of the system, there would be the least likelihood of a redundancy to supply another part. The advanced pregnancy of the female has no intelligible tendency to fill the breasts with milk. The lacteal system is a constant wonder; and it adds to other causes of our admiration, that the number of the teats and paps in each species is found to bear a proportion to the number of the young. In the sow, the bitch, the rabbit, the cat, the rat, which have numerous litters, the paps are numerous, and are disposed along the whole length of the belly: in the cow and mare, they are few. The most simple account of this, is to refer it to a designing Creator.

But in the argument before us, we are entitled to consider not only animal bodies when framed, but the circumstances under which they are framed: and in this view of the subject, the constitution of many of their parts is most strictly prospective.

III. The eye is of no use at the time when it is formed. It is an optical instrument made in a dungeon; constructed for the refraction of light to a focus, and perfect for its purpose, before a ray of light has had access to it; geometrically adapted to the properties and action of an element with which it has no communication. It is about indeed to enter into that communication; and this is precisely the thing which evidences intention. It is *providing* for the *future* in the closest sense which can be given to these terms; for it is providing for a future change, not for the then subsisting condition of the animal, not for any gradual progress or advance in that same condition, but for a new state, the consequence of a great and sudden alteration, which the animal is to undergo at its birth. Is it to be believed that the eye was formed, or, which is the same thing, that the series of causes was fixed by which the eye is formed, without a view to this change; without a prospect of that condition, in which its fabric, of no use at present, is about to be of the greatest; without a consideration of the qualities of that element, hitherto entirely excluded, but with which it was hereafter to hold so intimate a relation? A young

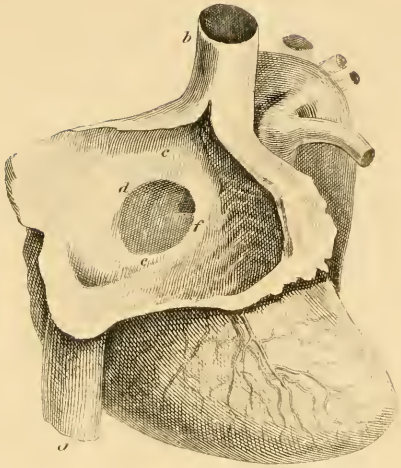
man makes a pair of spectacles for himself against he grows old; for which spectacles he has no want or use whatever at the time he makes them. Could this be done without knowing and considering the defect of vision to which advanced age is subject? Would not the precise suitableness of the instrument to its purpose, of the remedy to the defect, of the convex lens to the flattened eye, establish the certainty of the conclusion, that the case, afterwards to arise, had been considered beforehand, speculated upon, provided for? all which are exclusively the acts of a reasoning mind. The eye formed in one state, for use only in another state, and in a different state, affords a proof no less clear of destination to a future purpose, and a proof proportionably stronger, as the machinery is more complicated, and the adaptation more exact.

IV. What has been said of the eye, holds equally true of the lungs. Composed of air-vessels, where there is no air; elaborately constructed for the alternate admission and expulsion of an elastic fluid, where no such fluid exists; this great organ, with the whole apparatus belonging to it, lies collapsed in the fœtal thorax, yet in order, and in readiness for action, the first moment that the occasion requires its service. This is having a machine locked up in store for future use; which incontestably proves, that the case was expected to occur, in which this use might be experienced: but expectation is the proper act of intelligence.

Considering the state in which an animal exists before its birth, I should look for nothing less in its body than a system of lungs. It is like finding a pair of bellows in the bottom of the sea; of no sort of use in the situation in which they are found; formed for an action which was impossible to be exerted; holding no relation or fitness to the element which surrounds them, but both to another element in another place.

As part and parcel of the same plan, ought to be mentioned, in speaking of the lungs, the provisionary contrivances of the *foramen ovale* and *ductus arteriosus*. In the fœtus, pipes are laid for the passage of the blood through the lungs; but, until the lungs be inflated by the inspiration of air, that passage is impervious, or in a great degree obstructed. What then is to be done? what would a master do upon the occasion? He would endeavour, most probably, to provide a *temporary* passage, which might carry on the communication required, until the other was open. Now this is the thing which is actually done in the heart: instead of the circuitous route through the lungs, which the blood afterwards takes before it gets from one auricle of the heart to the other, a portion of the blood passes immediately from the right auricle to the left, through a hole placed in the partition which separates these cavities. This hole the anatomists call the *foramen ovale*.* There

* Tab. XXIX. Fig. 1. A view of the fœtal heart; *a*, the as-



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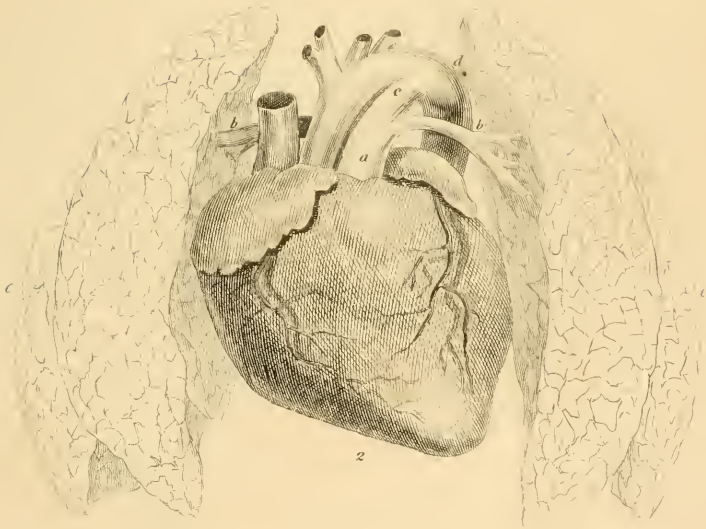

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is likewise another cross cut, answering the same purpose, by what is called the *ductus arteriosus*, lying between the pulmonary artery and the aorta.* But both expedients are so strictly temporary, that after birth the one passage is closed, and the tube which forms the other shrivelled up into a ligament. If this be not contrivance, what is?

But, forasmuch as the action of the air upon the blood in the lungs appears to be necessary to the perfect concoction of that fluid, *i. e.* to the life and health of the animal, (otherwise the shortest route might still be the best,) how comes it to pass that the *fœtus* lives and grows, and thrives, without it? The answer is, that the blood of the fœtus is the mother's; that it has undergone that action in her habit; that one pair of lungs serves for both. When the animals are separated, a new necessity arises; and to meet this necessity as soon as it occurs, an organization is prepared. It is ready for its purpose; it only waits for the atmosphere; it begins to play the moment the air is admitted to it.

cending, *b*, the descending vena cava; *c*, the right auricle; *d*, *e*, *f*, mark the elevated ring of the *foramen ovale*, or the opening betwen the two auricles.

* Fig. 2. The fœtal heart; *a*, the pulmonary artery; *b*, *b*, its branches; *c*, the *ductus arteriosus*, or canal for transmitting the blood into *d*, the aorta. As the lungs are useless in the fœtus, unless as a "prospective contrivance," the heart has to carry on a single circulation only; the free communication between the two auricles indentifies them as one cavity; and the ventricles also force the blood into one vessel, the aorta.

CHAPTER XV.

RELATIONS.

When several different parts contribute to one effect; or, which is the same thing, when an effect is produced by the joint action of different instruments; the fitness of such parts or instruments to one another, for the purpose of producing by their united action the effect, is what I call *relation;* and wherever this is observed in the works of nature or of man, it appears to me to carry along with it decisive evidence of understanding, intention, art. In examining, for instance, the several parts of a *watch*, the spring, the barrel, the chain, the fusee, the balance, the wheels of various sizes, forms, and positions, what is it which would take an observer's attention, as most plainly evincing a construction, directed by thought, deliberation, and contrivance? It is the suitableness of these parts to one another; first, in the succession and order in which they act; and, secondly, with a view to the effect finally produced. Thus, referring the spring to the wheels, our observer sees in it that which originates and upholds *their* motion; in the chain, that which transmits the motion to the fusee; in the fusee, that which communicates it to the wheels: in the conical figure of the fusee,

if he refer to the spring, he sees that which corrects the inequality of its force. Referring the wheels to one another, he notices, first, their teeth, which would have been without use or meaning, if there had been only one wheel, or if the wheels had had no connexion between themselves, or common bearing upon some joint effect; secondly, the correspondency of their position, so that the teeth of one wheel catch into the teeth of another; thirdly, the proportion observed in the number of teeth of each wheel, which determines the rate of going. Referring the balance to the rest of the works, he saw, when he came to understand its action, that which rendered their motions equable.* Lastly, in looking upon the index and face of the watch, he saw the use and conclusion of the mechanism, viz. marking the succession of minutes and hours; but all depending upon the motions within, all upon the system of intermediate actions between the spring and the pointer. What thus struck his attention in the several parts of the watch, he might probably designate by one general name of "relation;" and observing with respect to all cases whatever, in which the origin and formation of a thing could be ascertained by evidence, that these relations were found in things produced by art and design, and in no other things, he would rightly deem of them as characteristic of such pro-

* See Tab. I.

ductions.—To apply the reasoning here described to the works of nature.

The animal economy is full; is made up of these *relations* :—

I. There are, first, what in one form or other belong to all animals, the parts and powers which successively act upon their *food*. Compare this action with the process of a manufactory. In men and quadrupeds, the aliment is first broken and bruised by mechanical instruments of mastication, viz. sharp spikes or hard knobs, pressing against or rubbing upon one another: thus ground and comminuted, it is carried by a pipe into the stomach, where it waits to undergo a great chemical action, which we call digestion: when digested, it is delivered through an orifice,* which opens and shuts as there is occasion, into the first intestine; there, after being mixed with certain proper ingredients,† poured through a hole in the side of the vessel, it is farther dissolved; in this state, the milk, chyle, or part which is wanted, and which is suited for animal nourishment, is strained off by the mouths of very small tubes,‡ opening into the cavity of the intestines: thus freed from its grosser parts, the percolated fluid is carried by a long, winding, but

* The right aperture, termed the *Pylorus;* it divides the stomach and intestine, and is formed of circular muscular fibres interposed between the peritoneal and mucous membranes of the stomach.

† The bile and pancreatic fluids. See Tab. XVIII. and explanation.

‡ The lacteal vessels.

traceable course, into the main stream of the old circulation; which conveys it, in its progress, to every part of the body. Now I say again compare this with the process of a manufactory; with the making of cider, for example; with the bruising of the apples in the mill, the squeezing of them when so bruised in the press, the fermentation in the vat, the bestowing of the liquor thus fermented in the hogsheads, the drawing off into bottles, the pouring out for use into the glass. Let any one show me any difference between these two cases, as to the point of contrivance. That which is at present under our consideration, the "relation" of the parts successively employed, is not more clear in the last case than in the first. The aptness of the jaws and teeth to prepare the food for the stomach, is, at least, as manifest, as that of the cider-mill to crush the apples for the press. The concoction of the food in the stomach is as necessary for its future use, as the fermentation of the stum in the vat is to the perfection of the liquor. The disposal of the aliment afterwards; the action and change which it undergoes; the route which it is made to take, in order that, and until that, it arrive at its destination, is more complex indeed and intricate, but, in the midst of complication and intricacy, as evident and certain, as is the apparatus of cocks, pipes, tunnels, for transferring the cider from one vessel to another; of barrels and bottles for preserving it till fit for use, or of

cups and glasses for bringing it, when wanted, to the lip of the consumer. The character of the machinery is in both cases this; that one part answers to another part, and every part to the final result.

This parallel, between the alimentary operation and some of the processes of art, might be carried farther into detail. Spallanzani has remarked* a circumstantial resemblance between the stomachs of gallinaceous fowls and the structure of *corn-mills*. Whilst the two sides of the gizzard perform the office of the mill-stones, the craw or crop supplies the place of the *hopper*.

When our fowls are abundantly supplied with meat, they soon fill their craw: but it does not immediately pass thence into the gizzard; it always enters in very small quantities, in proportion to the progress of trituration; in like manner as, in a mill, a receiver is fixed above the two large stones which serve for grinding the corn; which receiver, although the corn be put into it by bushels, allows the grain to dribble only in small quantities, into the central hole in the upper mill-stone.†

But we have not done with the alimentary history. There subsists a general *relation* between the external organs of an animal by which it procures its food, and the internal powers by which it digests it. Birds of prey, by their talons

* Dis. I. Sect. liv.

† See anatomical structure of the gizzard described. Note p. 51.

and beaks, are qualified to seize and devour many species, both of other birds and of quadrupeds. The constitution of the stomach agrees exactly with the form of the members. The gastric juice of a bird of prey, of an owl, a falcon, or a kite, acts upon the animal fibre alone; it will not act upon seeds or grasses at all. On the other hand the conformation of the mouth of the sheep or the ox is suited for browsing upon herbage. Nothing about these animals is fitted for the pursuit of living prey. Accordingly it has been found by experiments, tried not many years ago, with perforated balls, that the gastric juice of ruminating animals, such as the sheep and the ox, speedily dissolves vegetables, but makes no impression upon animal bodies. This accordancy is still more particular. The gastric juice, even of granivorous birds, will not act upon the grain whilst whole and entire. In performing the experiment of digestion with the gastric juice in vessels, the grain must be crushed and bruised before it be submitted to the menstruum; that is to say, must undergo by art without the body, the preparatory action which the gizzard exerts upon it within the body; or no digestion will take place. So strict, in this case, is the relation between the offices assigned to the digestive organ, between the mechanical operation and the chemical process.

II. The relation of the kidneys to the bladder,

and of the ureters to both, *i. e.* of the secreting organ to the vessel receiving the secreted liquor, and the pipe laid from one to the other, for the purpose of conveying it from one to the other, is as manifest as it is amongst the different vessels employed in a distillery, or in the communications between them. The animal structure in this case being simple, and the parts easily separated, it forms an instance of correlation which may be presented by dissection to every eye, or which indeed without dissection, is capable of being apprehended by every understanding. This correlation of instruments to one another fixes intention somewhere; especially when every other solution is negatived by the conformation. If the bladder had been merely an expansion of the ureter, produced by retention of the fluid, there ought to have been a bladder for each ureter. One receptacle, fed by two pipes, issuing from different sides of the body, yet from both conveying the same fluid, is not to be accounted for by any such supposition as this.

III. Relation of parts to one another accompanies us throughout the whole animal economy. Can any relation be more simple, yet more convincing than this, that the eyes are so placed as to look in the direction in which the legs move and the hands work? It might have happened very differently if it had been left to chance. There were at least three quarters of the compass

out of four to have erred in. Any considerable alteration in the position of the eye, or the figure of the joints, would have disturbed the line, and destroyed the alliance between the sense and the limbs.

IV. But relation perhaps is never so striking as when it subsists, not between different parts of the same thing, but between different things. The relation between a lock and a key is more obvious than it is between different parts of the lock. A bow was designed for an arrow, and an arrow for a bow: and the design is more evident for their being separate implements.

Nor do the works of the Deity want this clearest species of relation. The *sexes* are manifestly made for each other. They form the grand relation of animated nature; universal, organic, mechanical: subsisting like the clearest relations of art, in different individuals; unequivocal, in explicable without design.

So much so, that were every other proof of contrivance in nature dubious or obscure, this alone would be sufficient. The example is complete. Nothing is wanting to the argument. I see no way whatever of getting over it.

V. The teats of animals which give suck, bear a relation to the mouth of the suckling progeny; particularly to the lips and tongue. Here also, as before, is a correspondency of parts; which parts subsist in different individuals.

These are *general* relations, or the relations of parts which are found, either in all animals, or in large classes and descriptions of animals. *Particular* relations, or the relations which subsist between the particular configuration of one or more parts of certain species of animals, and the particular configuration of one or more other parts of the same animal, (which is the sort of relation that is perhaps most striking,) are such as the following:

I. In the *swan;* the web-foot, the spoon-bill, the long neck, the thick down, the graminivorous stomach, bear all a relation to one another, inasmuch as they all concur in one design, that of supplying the occasions of an aquatic fowl, floating upon the surface of shallow pools of water, and seeking its food at the bottom. Begin with any one of these particularities of structure, and observe how the rest follow it. The web-foot qualifies the bird for swimming; the spoon-bill enables it to graze. But how is an animal, floating upon the surface of pools of water, to graze at the bottom, except by the mediation of a long neck? A long neck accordingly is given to it. Again, a warm-blooded animal, which was to pass its life upon water, required a defence against the coldness of that element. Such a defence is furnished to the swan, in the muff in which its body is wrapped. But all this outward apparatus would have been in vain, if the intestinal system had not been suited

to the digestion of vegetable substances. I say, suited to the digestion of vegetable substances: for it is well known, that there are two intestinal systems found in birds, one with a membranous stomach and a gastric juice, capable of dissolving animal substances alone; the other with a crop and gizzard, calculated for the moistening, bruising, and afterwards digesting, of vegetable aliment.

Or set off with any other distinctive part in the body of the swan; for instance, with the long neck. The long neck without the web-foot, would have been an incumbrance to the bird; yet there is no necessary connexion between a long neck and a web-foot. In fact they do not usually go together. How happens it, therefore, that they meet only when a particular design demands the aid of both?

II. This mutual relation, arising from a subserviency to a common purpose, is very observable also in the parts of a *mole*. The strong short legs of that animal, the palmated feet armed with sharp nails, the pig-like nose, the teeth, the velvet coat, the small external ear, the sagacious smell, the sunk protected eye, all conduce to the utilities or to the safety of its under-ground life. It is a special purpose, specially consulted throughout. The form of the feet fixes the character of the animal. They are so many shovels; they determine its action to that of rooting in the ground; and every thing about its body agrees with this

destination. The cylindrical figure of the mole, as well as the compactness of its form, arising from the terseness of its limbs, proportionably lessens its labour; because, according to its bulk, it thereby requires the least possible quantity of earth to be removed for its progress. It has nearly the same structure of the face and jaws as a swine, and the same office for them. The nose is sharp, slender, tendinous, strong; with a pair of nerves going down to the end of it. The plush covering, which, by the smoothness, closeness, and polish of the short piles that compose it, rejects the adhesion of almost every species of earth, defends the animal from cold and wet, and from the impediment which it would experience by the mould sticking to its body. From soils of all kinds the little pioneer comes forth bright and clean. Inhabiting dirt, it is, of all animals, the neatest.

But what I have always most admired in the mole is its *eyes*. This animal occasionally visiting the surface, and wanting, for its safety and direction, to be informed when it does so, or when it approaches it, a perception of light was necessary. I do not know that the clearness of sight depends at all upon the size of the organ. What is gained by the largeness or prominence of the globe of the eye, is width in the field of vision. Such a capacity would be of no use to an animal which was to seek its food in the dark.

The mole did not want to look about it; nor would a large advanced eye have been easily defended from the annoyance to which the life of the animal must constantly expose it. How indeed was the mole, working its way under ground, to guard its eyes at all? In order to meet this difficulty, the eyes are made scarcely larger than the head of a corking-pin; and these minute globules are sunk so deeply in the skull, and lie so sheltered within the velvet of its covering, as that any contraction of what may be called the eye-brows, not only closes up the apertures which lead to the eyes, but presents a cushion, as it were, to any sharp or protruding substance which might push against them. This aperture, even in its ordinary state, is like a pin-hole in a piece of velvet, scarcely pervious to loose particles of earth.

Observe then, in this structure, that which we call relation. There is no natural connexion between a small sunk eye and a shovel palmated foot. Palmated feet might have been joined with goggle eyes; or small eyes might have been joined with feet of any other form. What was it therefore which brought them together in the mole? That which brought together the barrel, the chain, and the fusee, in a watch; design: and design, in both cases, inferred from the relation which the parts bears to one another in the prosecution of a common purpose. As hath already

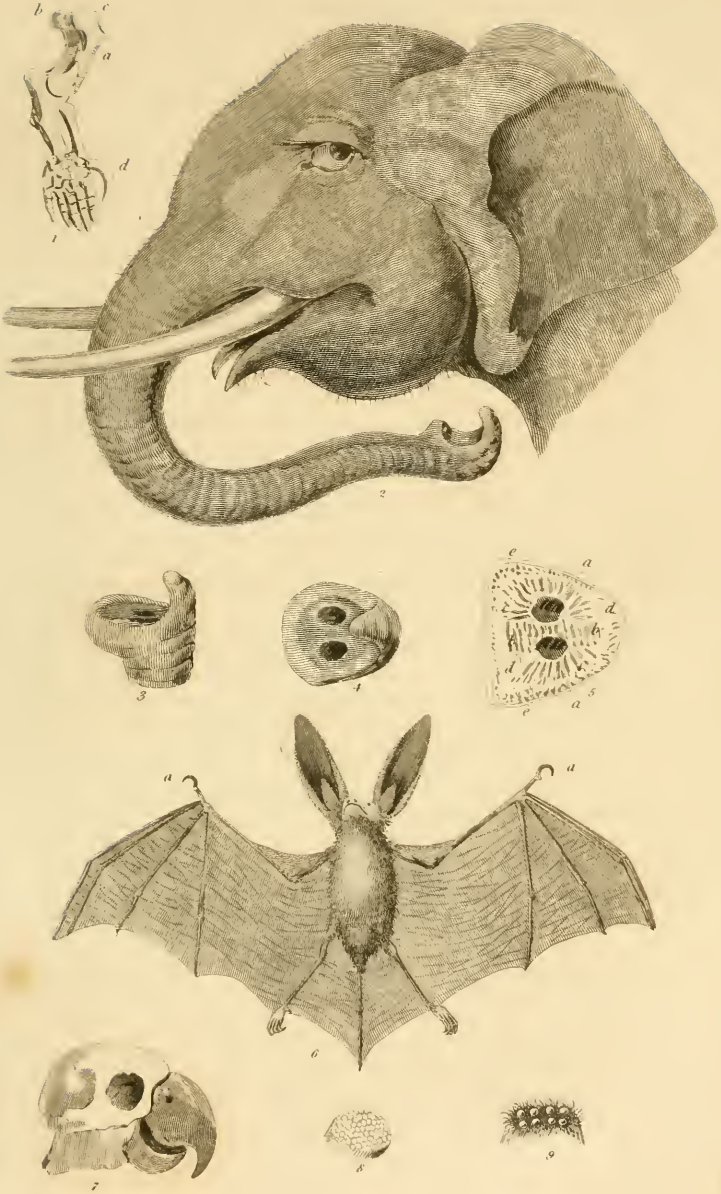
been observed, there are different ways of stating the relation, according as we set out from a different part. In the instance before us, we may either consider the shape of the feet, as qualifying the animal for that mode of life and inhabitation to which the structure of its eyes confines it; or we may consider the structure of the eye, as the only one which would have suited with the action to which the feet are adapted. The relation is manifest, whichever of the parts related we place first in the order of our consideration. In a word; the feet of the mole are made for digging; the neck, nose, eyes, ears, and skin, are peculiarly adapted to an under-ground life; and this is what I call relation.*

* Tab. XXX. Fig. 1. is the fore extremity of the *mole; a*, the *os humeri*, is peculiar, not only for its shortness, but in being articulated by *b*, one head to the scapula, and by *c*, another to the clavicle; it is altogether of such a nature as to turn the palm outwards for working.

The foot, or we may name it the hand, has ten bones in the *carpus* or *wrist*, which is two more than in the carpus of man. One of which, *d*, is remarkable, and from its shape is called the *falciform bone;* it gives the shovel form to the hand. The inclination outwards and backwards well answers the purpose of digging, and at the same moment throwing back the earth. The pectoral, and other muscles concerned in moving the extremity, have great strength, so that the animal digs its way with amazing force and rapidity.

Although the eye is exceedingly small, by the assistance of a magnifier the pupil, chrystalline lens, and vitreous humour may be plainly discovered.

"Insects also supply numberless exemplifications of the accurate adaptation of the structure of the organs of assimilation to the nature of the food which is to be converted into nutriment; and also of the general principle, that vegetable aliment requires, for this



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purpose, longer processes and a more complicated apparatus than that which has been already animalized. In the herbivorous tribes, we find the œsophagus either extremely dilatable, so as to serve as a crop or receptacle for containing the food previously to its digestion, or having a distinct pouch appended to it for the same object; to this there generally succeeds a gizzard or apparatus for trituration, furnished, not merely with a hard cuticle, as in birds, but also with numerous rows of teeth, of various forms, answering most effectually the purpose of dividing, or grinding into the minutest fragments, all the harder parts of the food; and thus supplying any deficiency of power in the jaws for accomplishing the same object. Thence the aliment, properly prepared, passes into the cavity appropriated for its digestion, which constitutes the true stomach. In the lower part of this organ, a peculiar fluid secretion is often intermixed with it, which has been supposed to be analogous to the bile of the higher animals. It is prepared by the coats of slender tubes, termed hepatic vessels, which are often of great length, and sometimes branched or tufted, or beset, like the fibres of a feather, with lateral rows of filaments; and which float loosely in the general cavity of the body attached only at their termination, where they open into the alimentary canal." See Dr. Roget's Bridgewater Treatise, vol. ii. p. 208.

In the *mantis religiosa*, which is purely a carnivorous insect, the whole canal is more simple, it is perfectly straight: commencing by an œsophagus of great length, which is preceded by a gizzard, hepatic vessels, and a digesting stomach, it is terminated by a short intestinal tube.

Of the perceptions of the lower animals and of the laws which they obey, our knowledge must, of necessity, be extremely imperfect, since it must be derived from a comparison with the results of our own sensitive powers, which may differ very essentially from those of the subjects of our observation. The same kind of organ which, in ourselves, convey certain definite feelings, may, when modified in other animals, be the source of very different kinds of sensations and perceptions, of which our minds have not the power to form any adequate conception. Many of the qualities of surrounding bodies, which escape our more obtuse senses, may be distinctly perceived, in all their gradations, by particular tribes of animals, furnished with more delicate organs. Many quadrupeds and birds possess powers of vision incomparably more extensive than our own; in acuteness of hearing, we are excelled by a great number of animals; and in delicacy of taste and smell, there are few quadrupeds who do not far surpass us. The organ of smell

CHAPTER XVI.

COMPENSATION.

Compensation is a species of relation. It is relation when the *defects* of one part, or of one organ, are supplied by the structure of another part, or of another organ. Thus,

I. The short unbending neck of the *elephant* is compensated by the length and flexibility of his *proboscis*. He could not have reached the ground without it; or, if it be supposed that he might have fed upon the fruit, leaves, or branches of trees, how was he to drink? Should it be asked, Why is the elephant's neck so short? it may be answered, that the weight of a head so heavy could not have been supported at the end of a longer lever. To a form, therefore, in some re-

in particular, is often spread over a vast extent of surface, in a cavity occupying the greatest part of the head; so that the perceptions of this sense must be infinitely diversified.

The perceptive powers of *insects* must embrace a very different, and, in many respects, more extended sphere than our own. These animals manifest by their actions, that they perceive and anticipate atmospheric changes, of which our senses give no information. But neither our thermometers, nor our electroscopes, nor hygrometers, nor our galvanometers, however skilfully devised or elaborately constructed, can vie in delicacy and perfection with that refined apparatus of the senses, which nature has bestowed on even the minutest insect. See Dr. Roget's Bridgewater Treatise, vol. ii. p. 571.

spects necessary, but in some respects also inadequate to the occasions of the animal, a supplement is added, which exactly makes up the deficiency under which he laboured.

If it be suggested that this proboscis may have been produced, in a long course of generations, by the constant endeavour of the elephant to thrust out his nose (which is the general hypothesis by which it has lately been attempted to account for the forms of animated nature,) I would ask, How was the animal to subsist in the mean time, during the process, *until* this prolongation of snout were completed? What was to become of the individual, whilst the species was perfecting?

Our business at present is, simply to point out the relation which this organ bears to the peculiar figure of the animal to which it belongs. And herein all things correspond. The necessity of the elephant's proboscis arises from the shortness of his neck; the shortness of the neck is rendered necessary by the weight of the head. Were we to enter into an examination of the structure and anatomy of the proboscis itself, we should see in it one of the most curious of all examples of animal mechanism.* The disposition of the ringlets

* Tab. XXX. Fig. 2. The head of the *elephant*. Fig. 3. and 4. the digitated extremity of the proboscis.

Fig. 5. A transverse section of the proboscis, shewing *a*, *a*, the two tubes or nostrils. Between the external integuments and the tubes are two sets of small muscles; an inner one running in a transverse, and an outward one in a longitudinal direction *b*, *b*,

and fibres, for the purpose, first, of forming a long cartilaginous pipe; secondly, of contracting and lengthening that pipe; thirdly, of turning it in every direction at the will of the animal; with the superaddition at the end, of a fleshy production, of about the length and thickness of a finger, and performing the office of a finger, so as to pick up a straw from the ground; these properties of the same organ, taken together, exhibit a specimen, not only of design (which is attested by the advantage,) but of consummate art, and, as I may say, of elaborate preparation, in accomplishing that design.

II. The hook in the wing of a *bat* is strictly a

the *transverse* faciculi of muscles, some of which run across the proboscis, others in a radiated, and some in an oblique direction: *c*, *c*, the radiated, and *d*, *d*, the oblique fibres approximate the skin and the tubes, without contracting the cavity of the latter. The others, which pass across the proboscis, contract both the surface of the organ, and the canals it contains; they can, at the same time, elongate the whole or a part of it: *e*, *e*, the *longitudinal* faciculi forming four large muscles, which occupy all the exterior of the organ. These are divided by tendinous intersections, and take their origin from the bones of the face. They give that extraordinary power which the animal possesses of moving the proboscis in every direction.

The tubes are prolongations of the external openings of the nose, and are lined by a strong tendinous membrane. They are separated from each other, and are both surrounded by adipose substance, which also is extended between the muscles we have already described. The outer part is covered by a tendinous expansion, and the common skin. The proboscis serves to pump up the drink which the animal takes in, as well as for smelling, breathing, and the various offices of feeding itself, &c. which most persons who have seen the animal must have witnessed with admiration.

mechanical, and also a *compensating* contrivance.* At the angle of its wing there is a bent claw, exactly in the form of a hook, by which the bat attaches itself to the sides of rocks, caves, and buildings, laying hold of crevices, joinings, chinks, and roughnesses. It hooks itself by this claw; remains suspended by this hold; takes its flight from this position: which operations compensate for the decrepitude of its legs and feet. Without her hook, the bat would be the most helpless of all animals. She can neither run upon her feet, nor raise herself from the ground. These inabilities are made up to her by the contrivance in her wing: and in placing a claw on that part, the Creator has deviated from the analogy observed in winged animals.—A singular defect required a singular substitute.

III. The *crane* kind are to live and seek their food amongst the waters; yet, having no web-feet, are incapable of swimming. To make up for this deficiency, they are furnished with long legs for wading, or long bills for groping; or usually with both.† This is *compensation*. But I think the

* Fig. 6. The extended wings of the bat. Osteologically considered they are hands, the bony stretchers of the membrane being the finger bones extremely elongated: *a*, *a*, the thumb is short, and armed with a hooked nail, which these animals make use of to hang by, and to creep. The hind feet are weak, and have toes of equal length, armed also with hooked nails; the membrane, constituting the wing, is continued from the feet to the tail.

† These are *waders*, a class of birds very numerous, and differing in interior and exterior conformation, but agreeing in this one

true reflection upon the present instance is, how every part of nature is tenanted by appropriate inhabitants. Not only is the surface of deep waters peopled by numerous tribes of birds that swim, but marshes and shallow pools are furnished with hardly less numerous tribes of birds that wade.

IV. The common *parrot* has, in the structure of its beak, both an inconveniency, and a *compensation* for it. When I speak of an inconveniency, I have a view to a dilemma which frequently occurs in the works of nature, viz. that the peculiarity of structure by which an organ is made to answer one purpose, necessarily unfits it for some other purpose. This is the case before us. The upper bill of the parrot is so much hooked, and so much overlaps the lower, that if, as in other birds, the lower chap alone had motion, the bird could scarcely gape wide enough to receive its food: yet this hook and overlapping of the bill could not be spared, for it forms the very instrument by which the bird climbs, to say nothing of the use which it makes of it in breaking nuts and the hard substances upon which it feeds. How, therefore, has nature provided for the opening of

particular, viz. that they are invariably bare of feathers to midway above the knees; by which peculiarity of structure they can, without inconvenience, wade in shallow water in search of food, which, for the most part, consists of fish, small aquatic animals, roots, and seeds.

In the ostrich and emu, which are unable to fly, the *compensation* is muscular and powerful limbs; so that their speed is equal to the swiftest horse.

this occluded mouth? By making the upper chap moveable,* as well as the lower. In most birds, the upper chap is connected, and makes but one piece with the skull; but in the parrot, the upper chap is joined to the bone of the head by a strong membrane placed on each side of it, which lifts and depresses it at pleasure.

V. The *spider's web* is a *compensating* contrivance. The spider lives upon flies without wings to pursue them; a case, one would have thought, of great difficulty, yet provided for, and provided for by a resource which no stratagem, no effort of the animal, could have produced, had not both its external and internal structure been specifically adapted to the operation.

VI. In many species of insects, the eye is fixed; and consequently without the power of turning the pupil to the object. This great defect is, however, perfectly *compensated;* and by a mechanism which we should not suspect. The eye is a multiplying glass,† with a lens looking in every

* Tab. XXX. Fig. 7. The upper *mandible* of the *parrot,* which is articulated with the cranium by an elastic ligament, admitting of a considerable degree of motion.

† The eyes of insects differ widely from vertebrated animals, by being incapable of motion; the compensation therefore is a greater number of eyes, or an eye compounded of a number of lenses. Kerby and Spence state the cornea of the eye of a common fly to contain an immense number of squares, with a lens of the same figure set in each. The same structure obtains in the *coleoptera* and many other insects. Reamur fitted an eye to a lens, and could see objects greatly multiplied through it. Hook computed

direction and catching every object. By which means, although the orb of the eye be stationary, the field of vision is as ample as that of other animals, and is commanded on every side. When this lattice-work was first observed, the multiplicity and minuteness of the surfaces must have added to the surprise of the discovery. Adams tells us, that fourteen hundred of these reticulations have been counted in the two eyes of a drone-bee.

In other cases the *compensation* is effected by the number and position of the eyes themselves.* The spider has eight eyes, mounted upon different parts of the head; two in front, two in the top of the head, two on each side. These eyes are without motion; but, by their situation, suited to comprehend every view which the wants or safety of the animal may render it necessary for it to take.

VII. The Memoirs for the Natural History of Animals, published by the French Academy, A. D

the lenses in a horsefly to amount to 7000, and Leuwenhoek found the almost incredible number of 12,000 in the dragon fly. In some insects however they are less numerous; in *Xnos* they do not exceed fifty, and are distinctly visible to the naked eye. The latter is the best example we can give of a compound eye. See Tab. XXX. Fig. 8.

* The number of eyes in insects varies from two to sixteen. The spider here referred to answers the description of the garden spider, (*Epeira* Diadema,) the eyes of which are planted on three tubercles, four on the central one, and two on each side of the lateral ones. Fig. 9. The eyes of a spider drawn from nature.

TAB. XXXI.

Nodes fe 352 Strand.

Published by J Vincent, Oxford.

1687, furnish us with some curious particulars in the eye of a chameleon. Instead of two eyelids, it is covered by an eyelid with a hole in it. This singular structure appears to be *compensatory*, and to answer to some other singularities in the shape of the animal. The neck of the chameleon is inflexible. To make up for this, the eye is so prominent, as that more than half of the ball stands out of the head; by means of which extraordinary projection, the pupil of the eye can be carried by the muscles in every direction, and is capable of being pointed towards every object. But then, so unusual an exposure of the globe of the eye requires, for its lubricity and defence, a more than ordinary protection of eyelid, as well as more than ordinary supply of moisture; yet the motion of an eyelid, formed according to the common construction, would be impeded, as it should seem, by the convexity of the organ. The aperture in the lid meets this difficulty. It enables the animal to keep the principal part of the surface of the eye under cover, and to preserve it in a due state of humidity without shutting out the light; or without performing every moment a nictitation, which it is probable, would be more laborious to this animal than to others.*

* Tab. XXXI. Fig. 1. The *chameleon*, drawn from one of the species preserved in the Anatomy School, Christ Church, Oxford. The eyes of this creature are very peculiar: they are remarkably large, and project more than half their diameter. They are covered with a single eye-lid, with a small opening in it opposite the

VIII. In another animal, and in another part of the animal economy, the same Memoirs describe a most remarkable *substitution*. The reader will remember what we have already observed concerning the *intestinal* canal; that its length, so many times exceeding that of the body, promotes the extraction of the chyle from the aliment, by giving room for the lacteal vessels to act upon it through a greater space. This long intestine, wherever it occurs, is in other animals disposed in the abdomen from side to side in returning folds. But, in the animal now under our notice, the matter is managed otherwise. The same intention is mechanically effectuated; but by a mechanism of a different kind. The animal of which I speak is an amphibious quadruped, which our authors call the alopecias, or sea-fox. The intestine is straight from one end to the other: but in this straight, and consequently short intestine, is a winding, corkscrew, spiral passage, through which the food, not without several circumvolutions, and in fact by a long route, is conducted to

pupil. The eye-lid is granulated like every part of the surface of the body, with this difference, over the eye of the granulations are disposed in concentric circles which form folds in that part to which the eye is turned: and as the lid is attached to the front of the eye, so it follows all its movements. The neck is not "inflexible," but its shortness, and the structure of the cervical vertebræ exceedingly limit the motion; this however is admirably compensated by the not less singular local position than motion of the eye, as the animal can see behind, before, or on either side, without turning the head.

its exit. Here the shortness of the gut is *compensated* by the obliquity of the perforation.*

IX. But the works of the Deity are known by expedients. Where we should look for absolute destitution; where we can reckon up nothing but wants; some contrivance always comes in to supply the privation. A *snail*, without wings, feet, or thread, climbs up the stalks of plants, by the sole aid of a viscid humour discharged from her skin. She adheres to the stems, leaves, and fruits of plants, by means of a sticking-plaster.† A *muscle*, which might seem, by its helplessness, to lie at the mercy of every wave that went over it, has the singular power of spinning strong tendinous threads, by which she moors her shell to rocks and timbers.‡ A *cockle*, on the contrary, by means

* Fig. 2. The spiral intestine of the *sea-fox*, taken from a preparation in the museum of the Royal College of Surgeons, London. The sea-fox is not, as above supposed, a "quadruped;" but a species of shark, (squalus vulpes.) The convoluted intestinal tube is also found in some other genera of fish. In this specimen the internal membrane is converted into a spiral valve, having thirty-six coils; so that the alimentary substances, instead of passing speedily away, by proceeding round the turns of the valve, traverse a very considerable circuit, which is thus provided for the action of the absorbent vessels. Fig. 3. The *spiral valve* removed, shewing the mode of its coiling.

† There is a viscid substance secreted from the body of the snail and slug, which enables it to attach one part of the body more firmly to the surface on which it is moving, while it drags up the remainder to a new position.

‡ This is performed by fixing on a point of rock the gluten which is furnished by a gland, situated at the base of the animal, which it draws out into threads while still soft, and which subsequently harden in the water into tenacious fibres.

of its stiff tongue,* works for itself a shelter in the sand. The provisions of nature extend to cases the most desperate. A *lobster* has in its constitution a difficulty so great, that one could hardly conjecture beforehand how nature would dispose of it. In most animals, the skin grows with their growth. If, instead of a soft skin, there be a shell, still it admits of a gradual enlargement. If the shell, as in the tortoise, consists of several pieces, the accession of substance is made at the sutures. Bivalve shells grow bigger by receiving an accretion at their edge; it is the same with spiral shells at their mouth. The simplicity of their form admits of this. But the lobster's shell being applied to the limbs of the body, as well as to the body itself, allows not of either of the modes of growth which are observed to take place in other shells. Its hardness resists expansion; and its complexity renders it incapable of increasing its size by addition of substance to its edge. How then was the growth of the lobster to be provided for? Was room to be made for it in the old shell, or was it to be successively fitted with new ones? If a change of shell became necessary, how was the lobster to extricate himself from his present confinement? How was he to uncase his buckler, or draw his legs out of his boots? The process,

* This organ is called the *foot*. In the razor-shell it is so constructed as to enable the animal to bury itself in the sand to the depth of two feet, in a few seconds.

which fishermen have observed to take place, is as follows: at certain seasons, the shell of the lobster grows soft; the animal swells its body; the seams open, and the claws burst at the joints. When the shell has thus become loose upon the body, the animal makes a second effort, and by a tremulous, spasmodic motion, casts it off. In this state, the liberated but defenceless fish retires into holes in the rock. The released body now suddenly pushes its growth. In about eight-and-forty hours, a fresh concretion of humour upon the surface, *i. e.* a new shell, is formed, adapted in every part to the increased dimensions of the animal. This wonderful mutation is repeated every year.

If there be imputed defects without compensation, I should suspect that they were defects only in appearance. Thus, the body of the *sloth* has often been reproached for the slowness of its motions, which has been attributed to an imperfection in the formation of its limbs. But it ought to be observed, that it is this slowness which alone suspends the voracity of the animal. He fasts during his migration from one tree to another; and this fast may be necessary for the relief of his overcharged vessels, as well as to allow time for the concoction of the mass of coarse and hard food which he has taken into his stomach. The tardiness of his pace seems to have reference to the capacity of his organs, and to his propensities with

respect to the food; *i. e.* is calculated to counteract the effects of repletion.*

Or there may be cases in which a defect is artificial, and compensated by the very cause which produces it. Thus the *sheep*, in the domesticated state in which we see it, is destitute of the ordinary means of defence or escape; is incapable either of resistance or flight. But this is not so with the wild animal. The natural sheep is swift and active; and if it lose these qualities when it comes under the subjection of man, the loss is compensated by his protection. Perhaps there is no species of quadruped whatever, which suffers so little as this does from the depredation of animals of prey.

For the sake of making our meaning better understood, we have considered this business of compensation under certain *particularities* of constitution, in which it appears to be most conspicu-

* Blumenbach states, in his Manual of Natural History, that he had conversed with many Hollanders who had lived in Guiana, and from them collected, that this apparently miserable animal is rather an enviable one. First, he nourishes himself entirely from leaves, and, therefore when he has once climbed a tree, he can live on the same dish a quarter of a year. Secondly, he does not drink at all. Thirdly, on a tree he is exposed to but few enemies, and when the sloth marks that a tiger-cat is climbing up a branch, it goes softly to the end of the branch, and rocks it till the tiger-cat falls off, so that seldom is there an instance that a tiger-cat surprises one: even upon the ground, so powerful are the claws of the sloth, and so fearful its cries, that its enemies generally get the worst. So idle is Buffon's declamation against the goodness and wisdom of Providence, drawn from this beast.

ous. This view of the subject necessarily limits the instances to single species of animals. But there are compensations, perhaps not less certain, which extend over large classes, and to large portions of living nature.

I. In quadrupeds, the deficiency of teeth is usually *compensated* by the faculty of rumination,* The sheep, deer, and ox tribe, are without fore-teeth in the upper jaw.† These ruminate. The horse and ass are furnished with teeth in the upper jaw, and do not ruminate. In the former class, the grass and hay descend into the stomach nearly in the state in which they are cropped from the pasture, or gathered from the bundle. In the stomach, they are softened by the gastric juice,

* The *ruminants* are cloven-footed animals; they have no incisor teeth in their upper jaw; they have four stomachs, and chew the cud.

The first stomach, called the *ventriculus*, or *paunch*, is a store-house for the food, which is afterwards thrown up to be remasticated and transmitted to the true digesting stomach.

The second, appears as a globular appendage termed the *reticulum*, or *honey-comb stomach*, from its inner surface being arranged into pentagonal cells.

The third stomach is the smallest, and called *amasum*, or *many plies*, from its consisting of numerous broad laminæ.

The fourth stomach, the *obomassum* or *reed*, has an elongated form, with longitudinal folds on its inner or mucous membrane, and is the only true digestive stomach. In young animals it has the power of curding milk.

† The teeth for masticating grain and herbs are remarkable; they have a flattish surface, and the jaw possesses a capacity for horizontal motion. That the surface of the cheek teeth should keep that sort of inequality peculiar to a mill-stone, their substance is composed of parts of unequal hardness, some of which parts wear sooner than others.

which in these animals is unusually copious. Thus softened and rendered tender, they are returned a second time to the action of the mouth, where the grinding teeth complete at their leisure the trituration which is necessary, but which was before left imperfect. I say, the trituration which is necessary; for it appears from experiments, that the gastric fluid of sheep, for example, has no effect in digesting plants, unless they have been previously masticated; that it only produces a slight maceration, nearly as common water would do in a like degree of heat; but that when once vegetables are reduced to pieces by mastication, the fluid then exerts upon them its specific operation. Its first effect is to soften them, and to destroy their natural consistency; it then goes on to dissolve them; not sparing even the toughest parts, such as the nerves of the leaves.*

I think it very probable, that the gratification also of the animal is renewed and prolonged by this faculty. Sheep, deer, and oxen, appear to be in a state of enjoyment whilst they are chewing the cud. It is then, perhaps, that they best relish their food.

II. In birds, the *compensation* is still more striking. They have no teeth at all. What have they then to make up for this severe want? I speak of granivorous and herbivorous birds; such as common fowls, turkeys, ducks, geese, pigeons, &c. for it is concerning these alone that the question need

* Spall. Dis. iii. sect. cxl.

be asked. All these are furnished with a peculiar and most powerful muscle called the *gizzard;** the inner coat of which is fitted up with rough plaits, which, by a strong friction against one another, break and grind the hard aliment as effectually, and by the same mechanical action, as a coffee-mill would do. It has been proved by the most correct experiments, that the gastric juice of these birds will not operate upon the *entire* grain; not even when softened by water or macerated in the crop. Therefore, without a grinding machine within its body, without the trituration of the gizzard, a chicken would have starved upon a heap of corn. Yet why should a bill and a gizzard go together? Why should a gizzard never be found where there are teeth?

Nor does the gizzard belong to birds as such. A gizzard is not found in birds of prey.† *Their*

* The *gizzard* of birds is the third stomach. It is of a globular figure, a little compressed, and it is composed of four immensely strong muscles. Two of these are situated laterally, and have fibres running in a radiated manner about two tendons placed at the sides of this organ. The other two muscles are much smaller than the former, and are situated at the extremities. The gizzard has an exterior tendinous covering, and within it is lined with a thick, strong callous coat; the density and hardness of which is said to compensate for the want of teeth. Herbivorous animals grind their food with their teeth, and then it passes into their stomach. On the contrary, birds of this sort first macerate and soften it in the crop, and then it is ground or comminuted in the gizzard. The small stones and gravel which are found in the gizzard of many birds, are supposed materially to assist a minute division or digestion of their food.

† In the majority of species which live on flesh or fish, the

food requires not to be ground down in a mill. The compensatory contrivance goes no farther than the necessity. In both classes of birds, however, the digestive organ within the body bears a strict and mechanical relation to the external instruments for procuring food.* The soft membranous stomach accompanies a hooked, notched beak; short, muscular legs; strong, sharp, crooked talons: the cartilaginous stomach attends that conformation of bill and toes, which restrains the bird to the picking of seeds, or the cropping of plants.

III. But to proceed with our *compensations*.— A very numerous and comprehensive tribe of terrestrial animals are entirely without feet; yet locomotive; and in a very considerable degree swift in their motion. How is the *want of feet* compensated? It is done by the disposition of the muscles and fibres of the trunk. In consequence of the just collocation, and by means of the joint action of longitudinal and annular fibres, that is to say, of strings and rings, the body and train of reptiles† are capable of being reciprocally short-

muscles of the gizzard are reduced to an extreme weakness, so as scarcely to be recognized, and this cavity makes only a single bag with the succentorial ventricle.

* Cuvier has observed that you never see in nature the cloven foot of the ox joined with the pointed fang of the lion, or the sharp talons of the eagle accompanying the flattened beak of the swan.

† Contraction and expansion is the mode of progression in *worms*, but not in *reptiles;* in the class of serpents locomotion consists simply of repeated horizontal undulations, viz. flexion and extension. Thus the head being the fixed point, the body and

ened and lengthened, drawn up and stretched out. The result of this action is a progressive, and in some cases, a rapid movement of the whole body, in any direction to which the will of the animal determines it. The meanest creature is a collection of wonders. The play of the rings in an *earth-worm*, as it crawls; the undulatory motion propagated along the body; the beards or prickles with which the annuli are armed, and which the animal can either shut up close to its body, or let out to lay hold of the roughness of the surface upon which it creeps; and the power arising from all these, of changing its place and position, affords, when compared with the provisions for motion in other animals, proofs of new and appropriate mechanism. Suppose that we had never seen an animal move upon the ground without feet, and that the problem was; muscular action, *i. e.* reciprocal contraction and relaxation being given, to describe how such an animal might be constructed, capable of voluntarily changing place.*

tail assume several curves; the tail then becomes the fixed point, the curvatures are straightened, and thus the animal advances with a *serpentine* motion. By these successive curvatures and right lines alternating, it moves forward at each *step* nearly the length of the whole body; the ribs, which Sir E. Home considers to act as feet, having nothing to do with locomotion unless as affording a fulcrum for the muscles.

* But there are other modes of moving, analagous to walking, performed by means of *suckers;* where the organ of motion is an uniform extended surface, as in the foot of the *limpet*, part of the foot is detached from the surface while the remaining points adhere by suction, until the others reach new points of support. Where

Something, perhaps, like the organization of reptiles might have been hit upon by the ingenuity of an artist; or might have been exhibited in an automaton, by the combination of springs, spiral wires, and ringlets; but to the solution of the problem would not be denied, surely, the praise of invention and of successful thought: least of all could it ever be questioned, whether intelligence had been employed about it, or not.

CHAPTER XVII.

THE RELATION OF ANIMATED BODIES TO INANIMATE NATURE.

We have already considered *relation*, and under different views; but it was the relation of parts to parts, of the parts of an animal to other parts of the same animal, or of another individual of the same species.

But the bodies of animals hold, in their con-

the organ of adhesion is double, one at each extremity, as in the *leech*, the mouth adheres to one part of the surface while the tail is brought up towards it, and is then fixed, the body being at the time like an arch. The head then quits its hold, the body extends itself, and the head again is attached and the tail brought up. By these alternate movements the leech advances at each *step* the length of its own body.

stitution and properties, a close and important relation to natures altogether external to their own; to inanimate substances, and to the specific qualities of these; e. g. *they hold a strict relation to the* ELEMENTS *by which they are surrounded.*

I. Can it be doubted, whether the *wings of birds* bear a relation to air, and the *fins of fish* to water? They are instruments of motion, severally suited to the properties of the medium in which the motion is to be performed: which properties are different. Was not this difference contemplated, when the instruments were differently constituted?

II. The structure of the animal *ear* depends for its use, not simply upon being surrounded by a fluid, but upon the specific nature of that fluid. Every fluid would not serve: its particles must repel one another, it must form an elastic medium: for it is by the successive pulses of *such* a medium, that the undulations excited by the surrounding body are carried to the organ; that a communication is formed between the object and the sense; which must be done before the internal machinery of the ear, subtile as it is, can act at all.

III. The *organs* of voice and respiration are, no less than the ear, indebted for the success of their operation to the peculiar qualities of the fluid in which the animal is immersed. They therefore, as well as the ear, are constituted upon the supposition of such a fluid, *i. e.* of a fluid with such par-

ticular properties, being always present. Change the properties of the fluid, and the organ cannot act; change the organ, and the properties of the fluid would be lost. The structure therefore of our organs, and the properties of our atmosphere, are made for one another. Nor does it alter the relation, whether you allege the organ to be made for the element, (which seems the most natural way of considering it,) or the element as prepared for the organ.

IV. But there is another fluid with which we have to do; with properties of its own; with laws of acting, and of being acted upon, totally different from those of air and water: and that is *light*. To this new, this singular element; to qualities perfectly peculiar, perfectly distinct and remote from the qualities of any other substance with which we are acquainted, an organ is adapted, an instrument is correctly adjusted, not less peculiar amongst the parts of the body, not less singular in its form, and in the substance of which it is composed, not less remote from the materials, the model, and the analogy of any other part of the animal frame, than the element to which it relates is specific amidst the substances with which we converse. If this does not prove appropriation, I desire to know what would prove it.

Yet the element of light and the organ of vision, however related in their office and use, have no connexion whatever in their original. The action

of rays of light upon the surfaces of animals, has no tendency to breed eyes in their heads. The sun might shine for ever upon living bodies, without the smallest approach towards producing the sense of sight. On the other hand also, the animal eye does *not* generate or emit light.

V. Throughout the universe there is a wonderful *proportioning* of one thing to another. The size of animals, of the human animal especially, when considered with respect to other animals, or to the plants which grow around him, is such, as a regard to his conveniency would have pointed out. A giant or a pigmy could not have milked goats, reaped corn, or mowed grass; we may add, could not have rode a horse, trained a vine, shorn a sheep, with the same bodily ease as we do, if at all. A pigmy would have been lost amongst rushes, or carried off by birds of prey.

It may be mentioned likewise, that the model and the materials of the human body being what they are, a much greater bulk would have broken down by its own weight. The persons of men who much exceed the ordinary stature, betray this tendency.

VI. Again (and which includes a vast variety of particulars, and those of the greatest importance;) how close is the *suitableness* of the earth and sea to their several inhabitants; and of these inhabitants, to the places of their appointed residence!

Take the *earth* as it is; and consider the correspondency of the powers of its inhabitants with the properties and condition of the soil which they tread. Take the inhabitants as they are; and consider the substances which the earth yields for their use. They can scratch its surface, and its surface supplies all which they want. This is the length of their faculties! and such is the constitution of the globe, and their own, that this is sufficient for all their occasions.

When we pass from the earth to the *sea*, from land to water, we pass through a great change; but an adequate change accompanies us, of animal forms and functions, of animal capacities and wants; so that *correspondency* remains. The earth in its nature is very different from the sea, and the sea from the earth; but one accords with its inhabitants as exactly as the other.

VII. The last relation of this kind which I shall mention, is that of *sleep* to *night;* and it appears to me to be a relation which was expressly intended. Two points are manifest: first, that the animal frame requires sleep;* secondly, that night

* "The animal frame requires sleep." For after the time of being awake has continued for sixteen or eighteen hours, we have a general feeling of fatigue and weakness; our motions become more difficult, our senses lose their activity, the mind becomes confused, receives sensations indistinctly, and governs muscular action with difficulty. We recognize by these signs the necessity of sleep;—we choose a position which can be preserved without effort. The *relation* of the stillness and obscurity of light to our

brings with it a silence, and a cessation of activity, which allows of sleep being taken without interruption, and without loss. Animal existence is made up of action and slumber; nature has provided a season for each. An animal which stood not in need of rest, would always live in day-light. An animal which, though made for action, and delighting in action, must have its strength repaired by sleep, meets by its constitution the returns of day and night. In the human species, for instance, were the bustle, the labour, the motion of life, upheld by the constant presence of light, sleep could not be enjoyed without being disturbed by noise, and without expense of that time which the eagerness of private interest would not contentedly resign. It is happy therefore for this part of the creation, I mean that it is conformable to the frame and wants of their constitution, that nature, by the very disposition of her elements, has commanded, as it were, and imposed upon them, at moderate intervals, a general in-

repose is striking, and calls for our adoration of an indulgent Creator.

The functions periodically rest, by the circulation, respiration, as well as the different secretions, and consequently digestion, becoming modified, or less rapid. By peaceful sleep, restrained within proper limits, the powers of our constitution are restored, and the organs recover their facility of action; but if sleep is troubled with unpleasant dreams, or painful impressions, or even prolonged beyond measure, very far from repairing, it exhausts the strength, and may become the occasion of disease.

termission of their toils, their occupations, and pursuits.

But it is not for man, either solely or principally, that night is made. Inferior, but less perverted natures, taste its solace, and expect its return with greater exactness and advantage than he does. I have often observed, and never observed but to admire, the satisfaction, no less than the regularity, with which the greatest part of the irrational world yield to this soft necessity, this grateful vicissitude: how comfortably the birds of the air, for example, address themselves to the repose of the evening; with what alertness they resume the activity of the day!

Nor does it disturb our argument to confess, that certain species of animals are in motion during the night, and at rest in the day. With respect even to them, it is still true, that there is a change of condition in the animal, and an external change corresponding with it. There is still the relation, though inverted. The fact is, that the repose of other animals sets these at liberty, and invites them to their food or their sport.

If the relation of *sleep* to *night*, and, in some instances, its converse, be real, we cannot reflect without amazement upon the extent to which it carries us. Day and night are things close to us; the change applies immediately to our sensations; of all the phenomena of nature, it is the most

obvious and the most familiar to our experience; but in its cause it belongs to the great motions which are passing in the heavens. Whilst the earth glides round her axle, she ministers to the alternate necessities of the animals dwelling upon her surface, at the same time that she obeys the influence of those attractions which regulate the order of many thousand worlds. The relation therefore of sleep to night, is the relation of the inhabitants of the earth to the rotation of their globe; probably it is more; it is a relation to the system, of which that globe is a part; and still farther, to the congregation of systems, of which theirs is only one. If this account be true, it connects the meanest individual with the universe itself: a chicken roosting upon its perch, with the spheres revolving in the firmament.

VIII. But if any one object to our representation, that the succession of day and night, or the rotation of the earth upon which it depends, is not resolvable into central attraction, we will refer him to that which certainly is,—to the change of the seasons. Now the constitution of animals susceptible of torpor, bears a relation to winter, similar to that which sleep bears to night. Against not only the cold, but the want of food which the approach of winter induces, the Preserver of the world has provided in many animals by migration, in many others by torpor.* As one example out

* In this country there are a few animals which, besides daily

of a thousand; the bat, if it did not sleep through the winter, must have starved, as the moths and flying insects upon which it feeds disappear. But the transition from summer to winter carries us into the very midst of physical astronomy; that is to say, into the midst of those laws which govern the solar system at least, and probably all the heavenly bodies.

CHAPTER XVIII.

INSTINCTS.

The order may not be very obvious, by which I place *instincts* next to relations. But I consider them as a species of relation. They contribute, along with the animal organization, to a joint effect, in which view they are related to that

repose, require annually some months of sleep. This is termed *hybernation*. The bat, hedge-hog, dormouse, &c. retire from active life, when there is a reduced temperature of the atmosphere, and when food is difficult to be obtained. These again revive when insects are sporting in the air, and the powers of vegetable life are exerted in the various processes of vegetation. Previous to their torpidity they have their bodies charged with fat, which is a sufficient store of nourishment during their profound slumbers, and is sufficient for their sustenance during the period of three or four months. For their temperature and respiration is greatly diminished, and their circulation, digestion, and every function of life proportionably languid. See Fleming's Philosophy of Zoology, article Torpidity.

organization. In many cases, they refer from one animal to another animal; and, when this is the case, become strictly relations in a second point of view.

An INSTINCT is a propensity prior to experience, and independent of instruction.* We contend, that it is by *instinct* that the sexes of animals seek each other; that animals cherish their offspring; that the young quadruped is directed to the teat of its dam; that birds build their nests, and brood with so much patience upon their eggs; that insects which do not sit upon their eggs, deposit them in those particular situations, in which the young, when hatched, find their appropriate food; that it is instinct which carries the salmon, and some other fish, out of the sea into rivers, for the purpose of shedding their spawn in fresh water.†

* In this chapter it is admirably proved, that animals are not abandoned by nature to chance or to themselves, they are all employed in a series of actions; hence result those marvellous propensities "independent of instruction." To incline animals to a punctual execution of those actions which are necessary for them, nature has provided them with *instinct;* that is, propensities, inclinations, and wants, by which they are excited to fulfil the intentions of nature. For this purpose we recognize in every animal a double design: 1st. self preservation; 2nd. the continuation of its own species; and every animal accomplishes this his own way, according to its organization.

† The salmon, the shad, the smelt, and the flounder, annually quit the ocean, and come up our rivers to deposit their spawn. On these occasions the salmon ascends rivers, sometimes a hundred miles from the sea, and surmounts the obstruction of high cataracts by leaping. It has been observed, that there is no danger which they will not encounter, to find a proper place for the deposition of their future offspring.

We may select out of *this* catalogue the incubation of eggs. I entertain no doubt, but that a couple of sparrows hatched in an oven, and kept separate from the rest of their species, would proceed as other sparrows do, in every office which related to the production and preservation of their brood. Assuming this fact, the thing is inexplicable upon any other hypothesis than that of an instinct impressed upon the constitution of the animal. For, first, what should induce the female bird to prepare a nest before she lays her eggs? It is in vain to suppose her to be possessed of the faculty of reasoning; for no reasoning will reach the case. The fulness or distension which she might feel in a particular part of her body, from the growth and solidity of the egg within her, could not possibly inform her, that she was about to produce something, which, when produced, was to be preserved and taken care of. Prior to experience, there was nothing to lead to this inference, or to this suspicion. The analogy was *all* against it; for, in every other instance, what issued from the body, was cast out and rejected.

But, secondly, let us suppose the egg to be produced into day; how should birds know that their eggs contain their young? There is nothing, either in the aspect or in the internal composition of an egg, which could lead even the most daring imagination to conjecture, that it was hereafter to turn out from under its shell, a living, perfect

bird. The form of the egg bears not the rudiments of a resemblance to that of the bird. Inspecting its contents, we find still less reason, if possible, to look for the result which actually takes place. If we should go so far, as, from the appearance of order and distinction in the disposition of the liquid substances which we noticed in the egg, to guess that it might be designed for the abode and nutriment of an animal, (which would be a very bold hypothesis,) we should expect a tadpole dabbling in the slime, much rather than a dry, winged, feathered creature; a compound of parts and properties impossible to be used in a state of confinement in the egg, and bearing no conceivable relation, either in quality or material, to any thing observed in it. From the white of an egg, would any one look for the feather of a goldfinch? or expect from a simple uniform mucilage, the most complicated of all machines, the most diversified of all collections of substances? Nor would the process of incubation, for some time at least, lead us to suspect the event. Who that saw red streaks shooting in the fine membrane which divides the white from the yolk, would suppose that these were about to become bones and limbs? Who that espied two discoloured points first making their appearance in the cicatrix, would have had the courage to predict, that these points were to grow into the heart and head

of a bird?* It is difficult to strip the mind of its experience. It is difficult to resuscitate surprise, when familiarity has once laid the sentiment asleep. But could we forget all that we know, and which *our* sparrows never knew, about oviparous generation; could we divest ourselves of every information, but what we derived from reasoning upon the appearance or quality discovered in the objects presented to us, I am convinced that Harlequin coming out of an egg upon the stage, is not more astonishing to a child, than the hatching of a chicken both would be, and ought to be, to a philosopher.

But admit the sparrow by some means to know, that within that egg was concealed the principle of a future bird; from what chemist was she to learn, that *warmth* was necessary to bring it to maturity, or that the degree of warmth, imparted by the temperature of her own body, was the degree required?

To suppose, therefore, that the female bird acts in this process from a sagacity and reason of her

* The first day of *incubation* produces a small shining point near the yolk-bag. The following day blood-vessels are distributed on its surface. On the third or fourth day, rudiments of a new formed heart, the *punctum saliens* is discerned. From the fourth to the eighth day all the principal parts of the chick are to be traced. On the fourteenth day ossification commences, and feathers appear. On the nineteenth day the animal is able to utter sounds, and on the twenty-first to break through its prison, and commence a second life. See Blumenbach Comp. Anat.

own, is to suppose her to arrive at conclusions which there are no premises to justify. If our sparrow, sitting upon her eggs, expect young sparrows to come out of them, she forms, I will venture to say, a wild and extravagant expectation, in opposition to present appearances, and to probability. She must have penetrated into the order of nature, farther than any faculties of ours will carry us; and it hath been well observed, that this deep sagacity, if it be sagacity, subsists in conjunction with great stupidity, even in relation to the same subject. "A chemical operation," says Addison, "could not be followed with greater art or diligence, than is seen in hatching a chicken; yet is the process carried on without the least glimmering of thought or common sense. The hen will mistake a piece of chalk for an egg; is insensible of the increase or diminution of their number; does not distinguish between her own and those of another species; is frightened when her supposititious breed of ducklings take the water."

But it will be said, that what reason could not do for the bird, observation, or instruction, or tradition, might. Now, if it be true, that a couple of sparrows, brought up from the first in a state of separation from all other birds, would build their nest, and brood upon their eggs, then there is an end of this solution. What can be the traditionary knowledge of a chicken hatched in an oven?

Of young birds taken in their nests, a few species breed when kept in cages; and they which do so, build their nests nearly in the same manner as in the wild state, and sit upon their eggs. This is sufficient to prove an instinct,* without having recourse to experiments upon birds hatched by artificial heat, and deprived from their birth of all communication with their species; for we can hardly bring ourselves to believe, that the parent bird informed her unfledged pupil of the history of her gestation, her timely preparation of her nest, her exclusion of the eggs, her long incubation, and of the joyful eruption at last of her expected offspring; all which the bird in the cage must have learnt in her infancy, if we resolve her conduct into *institution.*

Unless we will rather suppose, that she remembers her own escape from the egg; had attentively observed the conformation of the nest in which she was nurtured; and had treasured up her remarks for future imitation: which is not only extremely improbable, (for who, that sees a brood of callow birds in their nest, can believe that they are taking a plan of their habitation?) but leaves unaccounted for, one principal part of the difficulty, "the preparation of the nest before the laying of the egg." This she could not gain from observation in her infancy.

* As another instance; birds of passage kept in a cage, with plenty of food and in warm chambers, yet at the given season of migration manifest extreme restlessness, and attempt to escape.

It is remarkable also, that the hen sits upon eggs which she has laid without any communication with the male, and which are therefore necessarily unfruitful; that secret she is not let into. Yet, if incubation had been a subject of instruction or of tradition, it should seem that this distinction would have formed part of the lesson: whereas the instinct of nature is calculated for a state of nature; the exception here alluded to taking place chiefly, if not solely, amongst domesticated fowls, in which nature is forced out of her course.

There is another case of oviparous economy, which is still less likely to be the effect of education than it is even in birds, namely that of *moths* and *butterflies*, which deposit their eggs in the precise substance, that of a cabbage for example, from which, not the butterfly herself, but the caterpillar which is to issue from her egg, draws its appropriate food. The butterfly cannot taste the cabbage. Cabbage is no food for her; yet in the cabbage, not by chance, but studiously and electively, she lays her eggs. There are, amongst many other kinds, the willow-caterpillar and the cabbage-caterpillar: but we never find upon a willow the caterpillar which eats the cabbage; nor the converse. This choice, as appears to me, cannot in the butterfly proceed from instruction. She had no teacher in her caterpillar state. She never knew her parent. I do not see, therefore,

how knowledge, acquired by experience, if it ever were such, could be transmitted from one generation to another. There is no opportunity either for instruction or imitation. The parent race is gone, before the new brood is hatched. And if it be original reasoning in the butterfly, it is profound reasoning indeed. She must remember her caterpillar state, its tastes and habits; of which memory she shows no signs whatever. She must conclude from analogy (for here her recollection cannot serve her,) that the little round body which drops from her abdomen, will at a future period produce a living creature, not like herself, but like the caterpillar, which she remembers herself once to have been. Under the influence of these reflections, she goes about to make provision for an order of things, which she concludes will, some time or other, take place. And it is to be observed, that not a few out of many, but that all butterflies argue thus; all draw this conclusion; all act upon it.*

* The dragon-fly is an inhabitant of the air, and could not exist in water; yet in this element, which is alone adapted for her young, she drops her eggs.

Not less surprising is the parental instinct of the gad-fly, (*Gasterophilus equi*) whose larvæ are destined to be nourished in the stomach and intestines of the horse! How shall the parent convey them there? By a mode truly extraordinary—Flying round the animal she curiously poises her body while she deposits her eggs on the hairs of his skin. Whenever therefore the horse chances to lick the part of his body to which they are attached, they adhere to the tongue, and from thence pass into the stomach and intestines. And what increases our surprise is, that the fly

But suppose the address, and the selection, and the plan, which we perceive in the preparations which many irrational animals make for their young, to be traced to some probable origin; still there is left to be accounted for, that which is the source and foundation of these phenomena, that which sets the whole at work, the στοργὴ, the parental affection, which I contend to be inexplicable upon any other hypothesis than that of instinct.

For we shall hardly, I imagine, in brutes, refer their conduct towards their offspring to a sense of duty, or of decency, a care of reputation, a compliance with public manners, with public laws, or with rules of life built upon a long experience of their utility. And all attempts to account for the parental affection from association, I think, fail. With what is it associated? Most immediately with the throes of parturition, that is, with pain, and terror, and disease. The more remote, but not less strong association, that which depends upon analogy, is all against it. Every thing else which proceeds from the body, is cast away and rejected. In birds, is it the egg which the hen loves? or is it the expectation which she cherishes of a future progeny, that keeps her upon her nest? What cause has she to expect delight from her progeny? Can any rational answer be given to

places her eggs almost exclusively on the knee and the shoulder, on those parts the horse is sure to lick.

the question, why, prior to experience, the brooding hen should look for pleasure from her chickens? It does not, I think, appear, that the cuckoo ever knows her young; yet, in her way, she is as careful in making provision for them, as any other bird. She does not leave her egg in every hole.

The salmon suffers no surmountable obstacle to oppose her progress up the stream of fresh rivers. And what does she do there? She sheds a spawn, which she immediately quits, in order to return to the sea; and this issue of her body she never afterwards recognizes in any shape whatever. Where shall we find a motive for her efforts and her perseverance? Shall we seek it in argumentation, or in instinct?* The violet crab of Jamaica performs a fatiguing march of some months' continuance, from the mountains to the sea-side. When she reaches the coast, she casts her spawn into the open sea; and sets out upon her return home.†

* To this question we must answer that it is instinct; *blind instinct*, which, like every other vital phenomenon, evidently depends on organization, without knowledge of the end. With another mode of instinct is associated knowledge; this is *enlightened instinct;* the first belongs to animals, the second is particularly the gift to man. It inclines him to make provision for hunger, thirst, protection from the weather, and the desire of agreeable sensations; we say these are amongst many instinctive feelings, inducing him to concur in the established order of beings.

In this view of the subject we see contrivance on the part of the Creator, by providing an organization which supplies the place of foresight.

† The "violet crab." *Cancer ruricola*. It is of a blackish violet

Moths and butterflies, as hath already been observed, seek out for their eggs those precise situations and substances in which the offspring caterpillar will find its appropriate food. That dear caterpillar the parent butterfly must never see. There are no experiments to prove that she would retain any knowledge of it, if she did. How shall we account for her conduct? I do not mean for her art and judgment in selecting and securing a maintenance for her young, but for the impulse upon which she acts. What should induce her to exert any art, or judgment, or choice, about the matter? The undisclosed grub, the animal which she is destined not to know, can hardly be the object of a particular affection, if we deny the influence of instinct.* There is nothing, therefore, left to her, but that of which her nature seems incapable, an abstract anxiety for the general preservation of the species; a kind of patriotism; a solicitude lest the butterfly race should cease from the creation.

colour, and inhabits South America and its islands in mountainous woods near the sea; lives chiefly on land in holes, and crevices which it digs for itself. It migrates annually in vast numbers to the sea, to wash off its spawn; after this it returns to the mountains, and provides itself with burrows, in which it secretes itself by day, going out only by night to feed.

* Condillac wished, with Darwin, to take away all the wonderful from the constructiveness of birds and insects, and refer it to practice; but the fallacy of the supposition is evident. There are creatures, the silk-worm, for instance, which work once, and but once, and which could have had no previous practice, no instructor —their efforts must have been from instinct only.

Lastly, the principle of association will not explain the discontinuance of the affection when the young animal is grown up. Association, operating in its usual way, would rather produce a contrary effect. The object would become more necessary by habits of society: whereas birds and beasts, after a certain time, banish their offspring; disown their acquaintance; seem to have even no knowledge of the objects which so lately engrossed the attention of their minds, and occupied the industry and labour of their bodies. This change, in different animals, takes place at different distances of time from the birth; but the time always corresponds with the ability of the young animal to maintain itself; never anticipates it. In the sparrow tribe, when it is perceived that the young brood can fly and shift for themselves, then the parents forsake them for ever; and though they continue to live together, pay them no more attention than they do to other birds in the same flock. I believe the same thing is true of all gregarious quadrupeds.

In this part of the case, the variety of resources, expedients, and materials, which animals of the same species are said to have recourse to, under different circumstances, and when differently supplied, makes nothing against the doctrine of instincts. The thing which we want to account for, is the propensity. The propensity being there, it is probable enough that it may put the

animal upon different actions, according to different exigencies. And this adaptation of resources may look like the effect of art and consideration, rather than of instinct; but still the propensity is instinctive. For instance, suppose what is related of the woodpecker to be true, that, in Europe, she deposits her eggs in cavities, which she scoops out in the trunks of soft or decayed trees, and in which cavities the eggs lie concealed from the eye, and in some sort safe from the hand of man; but that, in the forests of Guinea and the Brazils, which man seldom frequents, the same bird hangs her nest to the twigs of tall trees; thereby placing them out of the reach of *monkeys* and *snakes; i.e.* that in each situation she prepares against the danger which she has most occasion to apprehend: suppose, I say, this to be true, and to be alleged, on the part of the bird that builds these nests, as evidence of a reasoning and distinguishing precaution, still the question returns, whence the propensity to build at all?*

Nor does parental affection accompany genera-

* The nest is usually formed in this manner: when the time of incubation approaches they collect a fibrous moss, not very unlike hair; this, therefore, the bird first glues by some viscid substance gathered in the forest, to the extreme branch of a tree, then building downwards adds fresh materials to those already procured, and a nest is formed that depends, like a pouch, from the point of the branch: the hole to enter at is on the side; the interior is lined with the finer fibres of the same substance which composes the whole.

The Oriols of North America are a class of birds which build in this manner to avoid the snakes.

tion by any universal law of animal organization, if such a thing were intelligible. Some animals cherish their progeny with the most ardent fondness, and the most assiduous attention; others entirely neglect them; and this distinction always meets the constitution of the young animal, with respect to its wants and capacities. In many, the parental care extends to the young animal; in others, as in all oviparous fish, it is confined to the egg, and even, as to that, to the disposal of it in its proper element. Also, as there is generation without parental affection, so is there parental instinct, or what exactly resembles it, without generation. In the bee tribe, the grub is nurtured neither by the father nor the mother, but by the neutral bee. Probably the case is the same with ants.

I am not ignorant of the theory which resolves instinct into sensation; which asserts, that what appears to have a view and relation to the future, is the result only of the present disposition of the animal's body, and of pleasure or pain experienced *at the time*. Thus the incubation of eggs is accounted for by the pleasure which the bird is supposed to receive from the pressure of the smooth convex surface of the shells against the abdomen, or by the relief which the mild temperature of the egg may afford to the heat of the lower part of the body, which is observed at this time to be increased beyond its usual state. This

present gratification is the only motive with the hen for sitting upon her nest; the hatching of the chickens is, with respect to her, an accidental consequence. The affection of viviparous animals for their young is, in like manner, solved by the relief, and perhaps the pleasure, which they receive from giving suck. The young animal's seeking, in so many instances, the teat of its dam, is explained from its sense of smell, which is attracted by the odour of milk. The salmon's urging its way up the stream of fresh water rivers, is attributed to some gratification or refreshment, which, in this particular state of the fish's body, she receives from the change of element. Now of this theory it may be said,

First, that of the cases which require solution, there are few to which it can be applied with tolerable probability; that there are none to which it can be applied without strong objections, furnished by the circumstances of the case. The attention of the cow to its calf, and of the ewe to its lamb, appear to be prior to their sucking. The attraction of the calf or lamb to the teat of the dam, is not explained by simply referring it to the sense of smell. What made the scent of milk so agreeable to the lamb, that it should follow it up with its nose, or seek with its mouth the place from which it proceeded? No observation, no experience, no argument could teach the new dropped animal, that the substance from which

the scent issued was the material of its food. It had never tasted milk before its birth. None of the animals, which are not designed for that nourishment, ever offer to suck, or to seek out any such food. What is the conclusion, but that the sugescent parts of animals are fitted for their use, and the knowledge of that use put into them?

We assert, secondly, that, even as to the cases in which the hypothesis has the fairest claim to consideration, it does not at all lessen the force of the argument for intention and design. The doctrine of instincts is that of appetencies, *superadded* to the constitution of an animal, for the effectuating of a purpose beneficial to the species. The above stated solution would derive these appetencies from organization; but then this organization is not less specifically, not less precisely, and, therefore, not less evidently adapted to the same ends, than the appetencies themselves would be upon the old hypothesis. In this way of considering the subject, sensation supplies the place of foresight; but this is the effect of contrivance on the part of the Creator. Let it be allowed, for example, that the hen is induced to brood upon her eggs by the enjoyment or relief which, in the heated state of her abdomen, she experiences from the pressure of round smooth surfaces, or from the application of a temperate warmth. How comes this extraordinary heat or itching, or call it what you will, which you suppose to be the cause

of the bird's inclination, to be felt, just at the time when the inclination itself is wanted; when it tallies so exactly with the internal constitution of the egg, and with the help which that constitution requires in order to bring it to maturity? In my opinion this solution, if it be accepted as to the fact, ought to increase, rather than otherwise, our admiration of the contrivance. A gardener lighting up his stoves, just when he wants to force his fruit, and when his trees require the heat, gives not a more certain evidence of design. So again; when a male and female sparrow come together, they do not meet to confer upon the expediency of perpetuating their species. As an abstract proposition, they care not the value of a barley-corn, whether the species be perpetuated or not: they follow their sensations; and all those consequences ensue, which the wisest counsels could have dictated, which the most solicitous care of futurity, which the most anxious concern for the sparrow world could have produced. But how do these consequences ensue? The sensations, and the constitution upon which they depend, are as manifestly directed to the purpose which we see fulfilled by them; and the train of intermediate effects, as manifestly laid and planned with a view to that purpose; that is to say, design is as completely evinced by the phenomena, as it would be, even if we suppose the operations to begin, or to be carried on, from what some will allow to be

alone properly called instincts, that is, from desires directed to a future end, and having no accomplishment or gratification distinct from the attainment of that end.

In a word; I should say to the patrons of this opinion, be it so: be it, that those actions of animals which we refer to instinct, are not gone about with any view to their consequences, but that they are attended in the animal with a present gratification, and are pursued for the sake of that gratification alone; what does all this prove, but that the *prospection*, which must be somewhere, is not in the animal, but in the Creator?

In treating of the parental affection in brutes, our business lies rather with the origin of the principle, than with the effects and expressions of it. Writers recount these with pleasure and admiration. The conduct of many kinds of animals towards their young, has escaped no observer, no historian of nature. "How will they caress them," says Derham, "with their affectionate notes; lull and quiet them with their tender parental voice; put food into their mouths; cherish and keep them warm; teach them to pick, and eat, and gather food themselves; and, in a word, perform the part of so many nurses, deputed by the Sovereign Lord and preserver of the world, to help such young and shiftless creatures!" Neither ought it, under this head, to be forgotten, how

much the instinct *costs* the animal which feels it; how much a bird, for example, gives up, by sitting upon her nest: how repugnant it is to her organization, her habits, and her pleasures. An animal, formed for liberty, submits to confinement in the very season when every thing invites her abroad: what is more; an animal delighting in motion, made for motion, all whose motions are so easy and so free, hardly a moment, at other times, at rest, is, for many hours of many days together, fixed to her nest, as close as if her limbs were tied down by pins and wires. For my part, I never see a bird in that situation, but I recognize an invisible hand, detaining the contented prisoner from her fields and groves, for the purpose, as the event proves, the most worthy of the sacrifice, the most important, the most beneficial.

But the loss of liberty is not the whole of what the procreant bird suffers. Harvey tells us, that he has often found the female wasted to skin and bone by sitting upon her eggs.

One observation more, and I will dismiss the subject. The *pairing* of birds, and the *non-pairing* of beasts, forms a distinction between the two classes, which shows that the conjugal instinct is modified with a reference to utility founded on the condition of the offspring. In quadrupeds, the young animal draws its nutriment from the body of the dam. The male parent neither does, nor can contribute any part to its sustentation.

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In the winged race, the young bird is supplied by an importation of food, to procure and bring home which, in a sufficient quantity for the demand of a numerous brood, requires the industry of both parents. In this difference, we see a reason for the vagrant instinct of the quadruped, and for the faithful love of the feathered mate.

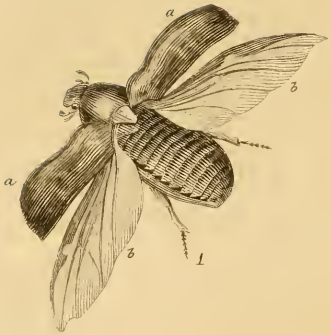
CHAPTER XIX.

OF INSECTS.

We are not writing a system of natural history; therefore we have not attended to the classes into which the subjects of that science are distributed. What we had to observe concerning different species of animals, fell easily, for the most part, within the divisions which the course of our argument led us to adopt. There remain, however, some remarks upon the *insect* tribe, which could not properly be introduced under any of these heads; and which therefore we have collected into a chapter by themselves.

The structure, and the use of the parts of insects, are less understood than that of quadrupeds and birds, not only by reason of their minuteness, or the minuteness of their parts, (for that minuteness we can in some measure follow with glasses,)

TAB. XXXII.



but also by reason of the remoteness of their manners and modes of life from those of larger animals. For instance: insects, under all their varieties of form, are endowed with *antennæ*, which is the name given to those long feelers that rise from each side of the head;* but to what common use or want of the insect kind, a provision so universal is subservient, has not yet been ascertained: and it has not been ascertained, because it admits not of a clear, or very probable comparison, with any organs which we possess ourselves, or with the organs of animals which resemble ourselves in their functions and faculties, or with which we are better acquainted than we are with insects. We want a ground of analogy. This difficulty stands in our way as to some particulars in the insect constitution, which we might wish to be acquainted with. Nevertheless, there are many contrivances in the bodies of insects, neither dubious in their use, nor obscure in their structure, and most properly mechanical. These form parts of *our* argument.

* Tab. XXXII. Fig. 2. *a*, *a*. *Antennæ* usually consist of a number of tubular joints, with a free motion in each, enabling the insect to give them every necessary flexure; they vary in number and in shape in the various orders, and are covered with hair, down, or bristles, frequently elegant and diversified, as every one may observe. Entomologists conceive, that the antennæ, by a peculiar structure, may collect notices from the atmosphere, receive vibrations, and communicate them to the sensorium, which, though not precisely to be called hearing, is something analogous to it, or may answer that purpose.

I. The *elytra*, or scaly wings of the genus of scarabæus or beetle, furnish an example of this kind. The true wing of the animal is a light transparent membrane, finer than the finest gauze, and not unlike it. It is also, when expanded, in proportion to the size of the animal, very large. In order to protect this delicate structure, and perhaps also to preserve it in a due state of suppleness and humidity, a strong hard case is given to it, in the shape of the horny wing which we call the elytron.* When the animal is at rest, the gauze wings lie folded up under this impenetrable shield. When the beetle prepares for flying, he raises the integument, and spreads out his thin membrane to the air. And it cannot be observed without admiration, what a tissue of cordage, *i. e.* of muscular tendons, must run in various and complicated, but determinate directions, along this fine surface, in order to enable the animal, either to gather it up into a certain precise form, whenever it desires to place its wings under the shelter which nature hath given to them; or

* Fig. 1. is an instance of the horny and gauze wings in one of the most beautiful of the beetle class of this country, the *cetonia aurata*, or rose chafer; shewing the expanded *elytra*, *a*, *a*: the true wings, *b*, *b*.

Elytra are the wing covers of all the *coleoptera* order. They are frequently grooved, and curiously ornamented, in some species with scaly variegations of metallic lustre, as in the diamond beetle, and some species of Buprestis. One of the latter, of extraordinary brilliancy, forms an object in the "Cabinet of Beauty" in the Ashmolean Museum. The use of the elytra is to protect the wings and body; and they are of some assistance in flying.

to expand again their folds, when wanted for action.

In some insects, the elytra cover the whole body; in others, half;* in others, only a small part of it; but in all,† they completely hide and cover the true wings. Also,

Many or most of the beetle species lodge in holes in the earth, environed by hard rough substances, and have frequently to squeeze their way through narrow passages; in which situation, wings so tender, and so large, could scarcely have escaped injury, without both a firm covering to defend them, and the capacity of collecting themselves up under its protection.

II. Another contrivance, equally mechanical and equally clear, is the *awl*,‡ or borer, fixed at the tails of various species of flies; and with which they pierce, in some cases, plants; in others, wood; in others, the skin and flesh of animals;

* Fig. 2. A specimen of this kind of elytra in the ear-wig: (*forficula borealis:*) the elytra are extended, and the membranous wings unfolded; shewing the numerous diverging *nervures* or "muscular tendons," which run in horny tubes to keep the wing extended.

† Some instances however are known, as in *molorchus* and *atractocarus*, &c. where the wings are only partially covered by the elytra, and not folded under them; probably these are less in danger of laceration from their peculiar habits, than the generality.

‡ Called the *ovipositor*, or instrument by which the numerous insects are enabled to introduce their eggs into their appropriate situations, and where the new born larva may immediately meet with its destined food.

in others, the coat of the chrysalis of insects of a different species from their own; and in others, even lime, mortar, and stone. I need not add, that having pierced the substance, they deposit their eggs in the hole. The descriptions which naturalists give of this organ, are such as the following: it is a sharp-pointed instrument, which, in its inactive state, lies concealed in the extremity of the abdomen, and which the animal draws out at pleasure, for the purpose of making a puncture in the leaves, stem, or bark, of the particular plant which is suited to the nourishment of its young. In a sheath which divides and opens whenever the organ is used, there is enclosed a compact, solid, dentated stem, along which runs a *gutter*, or *groove*, by which groove, after the penetration is effected, the egg, assisted in some cases by a peristaltic motion, passes to its destined lodgement.* In the œstrus or gad-fly, the wimble *draws out* like the pieces of a spy-glass; the last piece is armed with three hooks, and is able to bore through the hide of an ox.† Can any thing

* There are numerous variations in the structure of this organ; an example of the one just mentioned is seen in the ovipositor of the *buprestis*, Fig. 2. It consists of three long and sharp laminæ, the two lateral ones forming a sheath to the intermediate one, which is the tube which conveys the egg. In some cases the instrument forms a saw, or what Paley here calls a dentated stem, which conveys the eggs, as in the *tenthredo*, *cicidæ*, *cimbex*, &c.

† Fig. 3. The *awl* of the *œstrus bovis*, or gad-fly, highly magnified. It is formed of corneus substance, consisting of four joints, which slip into each other; the last of these terminate in five

more be necessary to display the mechanism, than to relate the fact?

III. The *stings* of insects, though for a different purpose, are, in their structure, not unlike the piercer. The sharpness to which the point in all of them is wrought; the temper and firmness of the substance of which it is composed; the strength of the muscles by which it is darted out, compared with the smallness and weakness of the insect, and with the soft and friable texture of the rest of the body; are properties of the sting to be noticed, and not a little to be admired. The sting of a *bee* will pierce through a goat-skin glove. It penetrates the human flesh more readily than the finest point of a needle. The *action* of the sting affords an example of the union of chemistry and mechanism, such as, if it be not a proof of contrivance, nothing is. First, as to the chemistry; how highly concentrated must be the *venom*, which, in so small a quantity, can produce such powerful effects! And in the bee we may observe, that this venom is made from *honey*, the only food of the insect, but the last material from which I should have expected that an exalted poison could, by any process or digestion whatsoever, have been prepared. In the next place, with respect to the

points, three of which are longer than the others, and are hooked: when united, they form an instrument like an auger or gimblet, with which the skin is pierced in a few seconds.

Fig. 4. One of the *hooks*.

mechanism, the sting is not a simple, but a compound instrument. The visible sting, though drawn to a point exquisitely sharp, is, in strictness, only a sheath; for, near to the extremity may be perceived, by the microscope, two minute orifices, from which orifices, in the act of stinging, and, as it should seem, after the point of the main sting has buried itself in the flesh, are launched out two subtile rays, which may be called the true or proper stings, as being those through which the poison is infused into the puncture already made by the exterior sting.* I have said, that chemistry and mechanism are here *united:* by which observation I meant, that all this machinery would have been useless, *telum imbelle*, if a supply of poison, intense in quality, in proportion to the smallness of the drop, had not been furnished to it by the chemical elaboration which was carried on in the insect's body; and that, on the other hand, the poison, the result of this process, could not have attained its effect, or reached its enemy, if, when it was collected at the extremity of the abdomen, it had not found there a machinery, fitted to conduct it to the external situations in which it was to operate, *viz.* an awl to bore a hole, and a syringe to inject the fluid. Yet these attri-

* Fig. 5. The *sting of a bee*, drawn from nature as it appears by means of a magnifier of very high powers; *a*, *a*, *a*, *a*, the apparatus for projecting the sting; *b*, the exterior, *c*, the interior sheath of *d*, the *true sting*, which is divided into two parts barbed at the sides; *e*, the bag which contains the *poison*.

butes, though combined in their action, are independent in their origin. The venom does not breed the sting; nor does the sting concoct the venom.

IV. The *proboscis*,* with which many insects are endowed, comes next in order to be considered. It is a tube attached to the head of the animal. In the bee, it is composed of two pieces connected by a joint: for if it were constantly extended, it would be too much exposed to accidental injuries; therefore, in its indolent state, it is doubled up by means of the joint, and in that position lies secure under a scaly penthouse.† In many species of the butterfly, the proboscis, when not in use, is coiled up like a watch-spring.‡ In the same bee, the proboscis serves the office of the mouth, the insect having no other: and how much better adapted it is, than a mouth would be, for collecting of the proper nourishment of the animal, is sufficiently evident. The food of the bee is the nectar of flowers; a drop of syrup, lodged deep in the bottom of the corollæ, in the recesses of the petals, or down the neck of a monopetalous glove. Into these cells the bee thrusts its long narrow pump, through the cavity of which it sucks up this precious fluid, inaccessible to every other

* Fig. 6. The proboscis of a *bombus* extended; *a*, *a*, the case or sheath; *b*, the tube; *c*, the exterior; *d*, the interior fringes; *e*, the tongue; *f*, *f*, the exterior; *g*, *g*, the interior palpi.

† Fig. 7. The appearance of the proboscis when contracted, and folded up.

‡ Fig. 8. The head of a butterfly, shewing the *coiled proboscis*.

approach. It is observable also, that the plant is not the worse for what the bee does to it. The harmless plunderer rifles the sweets, but leaves the flower uninjured. The ringlets of which the proboscis of the bee is composed, the muscles by which it is extended and contracted, form so many microscopical wonders. The agility also with which it is moved, can hardly fail to excite admiration. But it is enough for our purpose to observe in general, the suitableness of the structure to the use, of the means to the end, and especially the wisdom by which nature has departed from its most general analogy (for animals being furnished with mouths are such,) when the purpose could be better answered by the deviation.

In some insects, the proboscis, or tongue, or trunk, is shut up in a sharp-pointed sheath; which sheath, being of a much firmer texture than the proboscis itself, as well as sharpened at the point, pierces the substance which contains the food, and then *opens within the wound*, to allow the enclosed tube, through which the juice is extracted, to perform its office. Can any mechanism be plainer than this is; or surpass this?

V. The *metamorphosis* of insects from grubs into moths and flies, is an astonishing process.* A hairy

* The first state in which an insect appears, is that of an *ovum* or egg. This relates to the generality of insects, for there are a few examples of viviparous insects, as in the genus aphis, musca, &c. These undergo no change, but the casting their skin from

caterpillar is transformed into a butterfly. Observe the change. We have four beautiful wings, where there were none before; a tubular proboscis, in the place of a mouth with jaws and teeth; six long legs, instead of fourteen feet. In another case, we see a white, smooth, soft worm, turned into a black, hard, crustaceous beetle, with gauze wings. These, as I said, are astonishing processes, and must require, as it should seem, a proportionably artificial apparatus. The hypothesis which appears to me most probable is, that, in the grub, there exist at the same time three animals, one within another, all nourished by the same digestion, and by a communicating circulation; but in different stages of maturity. The latest discoveries made by naturalists seem to favour this supposition. The insect already equipped with wings, is descried under the

time to time, till at length they acquire the complete resemblance to the parent animal.

From the egg is hatched the insect in its second *larva*, or *caterpillar* state, in which it is extremely voracious.

In the third state, viz: that of *pupa* or *chrysalis*, it ceases to feed: they are then inclosed in a web, which they spin about themselves, or in a shell-like case, and in the fly-tribe is without apparent motion. The libellulæ or dragon-fly, however, as Paley subsequently observes, as well as the pupæ of the locust tribe, is locomotive.

After remaining a proper period in this situation, the bonds which surround them are broken, and the fourth state is that in which the insect emerges from the pupa or chrysalis, in its complete and ultimate form; from which it can neither change, or receive any further increase of growth. This last state is a winged insect, in the Linnæan language termed *imago*.

membranes both of the worm and nymph. In some species, the proboscis, the antennæ, the limbs and wings of the fly, have been observed to be folded up within the body of the caterpillar; and with such nicety as to occupy a small space only under the two first wings. This being so, the outermost animal, which, besides its own proper character, serves as an integument to the other two, being the farthest advanced, dies, as we suppose, and drops off first. The second, the pupa or chrysalis, then offers itself to observation. This also in its turn dies; its dead and brittle husk falls to pieces, and makes way for the appearance of the fly or moth. Now, if this be the case, or indeed whatever explication be adopted, we have a prospective contrivance of the most curious kind; we have organizations *three deep;* yet a vascular system, which supplies nutrition, growth, and life, to all of them together.

VI. Almost all insects are oviparous. Nature keeps her butterflies, moths, and caterpillars, locked up during the winter in their egg state; and we have to admire the various devices to which, if we may so speak, the same nature hath resorted, for the *security* of the egg. Many insects enclose their eggs in a silken web; others cover them with a coat of hair torn from their own bodies; some glue them together; and others, like the moth of the silkworm, glue them to the leaves upon which they are deposited, that they

may not be shaken off by the wind, or washed away by rain: some again make incisions into leaves, and hide an egg in each incision; whilst some envelope their eggs with a soft substance, which forms the first aliment of the young animal: and some again make a hole in the earth, and having stored it with a quantity of proper food, deposit their eggs in it. In all which we are to observe, that the expedient depends, not so much upon the address of the animal, as upon the physical resources of his constitution.*

The art also with which the young insect is *coiled up* in the egg, presents, where it can be examined, a subject of great curiosity. The insect, furnished with all the members which it ought to have, is rolled up into a form which seems to contract it into the least possible space; by which contraction, notwithstanding the smallness of the egg, it has room enough in its apartment, and to spare. This folding of the limbs appears to me to indicate a special direction, for, if it were merely the effect of compression, the collocation of the parts would

* The above describes only a part of the varied situations which insects select to deposit their eggs; some set their eggs afloat, or submerge them in water, as the *gnats* and *tipulidans*. But the *lackey moth* lays its eggs in autumn, and they are not hatched till spring; the female does not, therefore, "like most other moths, place her eggs upon a leaf, with which they might be blown by the wintry storm far from their destined food; but round the twig of some tree she ranges them in numerous circles, deposited with so much art, that you would take them rather for pearls set by the skilful hand of a jeweller, than for the eggs of an insect."

be more various than it is. In the same species, I believe, it is always the same.

These observations belong to the whole insect tribe, or to a great part of them. Other observations are limited to fewer species; but not, perhaps, less important or satisfactory.

I. The organization in the abdomen of the *silk-worm*,* or *spider*, whereby these insects form their *thread*, is as incontestably mechanical as a wire-drawer's mill. In the body of the silk-worm are two bags, remarkable for their form, position, and use. They wind round the intestine; when drawn out, they are ten inches in length, though the animal itself be only two. Within these bags is collected a glue; and communicating with the bags, are two paps or outlets, perforated like a grater, by a number of small holes. The glue or gum, being passed through these minute apertures, form hairs of almost imperceptible fineness; and these hairs, when joined, compose the silk which we wind off from the cone, in which the silk-worm has wrapped itself up: in the spider, the web is formed from this thread. In both cases, the extremity of the thread, by means of

* The organs for forming the silk, or *silk secretors*, (sericteria,) are most remarkable in the caterpillars of the *nocturnal leipedoptera* or moths, especially in the *bombyces*, to which the silk-worm belongs. Which consist, as above stated, of two long vessels, where they unite to form the *spinneret* (fusulus) through which the larva draws the silken thread employed in fabricating its cocoon. Tab. XXXIII. Fig. 1. *a*, *a*, the *silk bags*, *b*, the *spinneret*.

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its adhesive quality, is first attached by the animal to some external hold; and the end being now fastened to a point, the insect, by turning round its body, or by receding from that point, draws out the thread through the holes above described, by an operation, as hath been observed, exactly similar to the drawing of wire. The thread, like the wire, is formed by the hole through which it passes. In one respect there is a difference. The wire is the metal unaltered, except in figure. In the animal process, the nature of the substance is somewhat changed as well as the form; for, as it exists within the insect, it is a soft clammy gum or glue. The thread acquires, it is probable, its firmness and tenacity from the action of the air upon its surface, in the moment of exposure; and a thread so fine is almost all surface. This property, however, of the paste is part of the contrivance.*

The mechanism itself consists of the bags or reservoirs into which the glue is collected, and

* The web of spiders is also a kind of silk, remarkable for its lightness and tenuity; it is spun from four or six anal spinnerets, the fluid matter forming the web being secreted in adjacent vessels. When the threads have been drawn through this machinery, they unite at a small distance from the spinnerets, and form one compound thread. Each thread, however, before united, is formed of numerous filaments, to be detected only by a microscope. The probable reason of this so complex a contrivance is, that it was necessary that the gummy secretion might sufficiently dry so as to form a tenacious line, a purpose admirably effected by the minute division. See Fig. 2. *a*, *b*, *c*, *d*, the *spinnerets*.

of the external holes communicating with these bags: and the action of the machine is seen in the forming of a thread, as wire is formed, by forcing the material already prepared through holes of proper dimensions. The secretion is an act too subtile for our discernment, except as we perceive it by the produce. But one thing answers to another; the secretory glands to the quality and consistence required in the secreted substance; the bag to its reception: the outlets and orifices are constructed, not merely for relieving the reservoirs of their burden, but for manufacturing the contents into a form and texture, of great external use, or rather indeed of future necessity, to the life and functions of the insect.

II. *Bees*, under one character or other, have furnished every naturalist with a set of observations. I shall in this place confine myself to one: and that is, the *relation* which obtains between the wax and the honey. No person, who has inspected a bee-hive, can forbear remarking how commodiously the honey is bestowed in the comb; and, amongst other advantages, how effectually the fermentation of the honey is prevented by distributing it into small cells. The fact is, that when the honey is separated from the comb, and put into jars, it runs into fermentation with a much less degree of heat than what takes place in a hive. This may be reckoned a nicety; but, independently of any nicety in the matter, I

would ask, what could the bee do with the honey if it had not the wax? how, at least, could it store it up for winter? The wax, therefore, answers a purpose with respect to the honey; and the honey constitutes that purpose with respect to the wax. This is the relation between them. But the two substances, though together of the greatest use, and without each other of little, come from a different origin. The bee finds the honey,* but makes the wax. The honey is lodged in the nectaria of flowers, and probably undergoes little alteration; is merely collected: whereas the wax is a ductile, tenacious paste, made out of a dry powder, not simply by kneading it with a liquid, but by a digestive process in the body of the bee.† What account can be rendered of facts so circumstanced, but that the animal, being intended to feed upon honey, was, by a peculiar external configuration, enabled to procure it? That, moreover,

* The *honey* is collected by the bee from that part of the flower called the *nectary*, by means of the proboscis, and is received into an oval receptacle termed the first stomach or honey bag; and when this is sufficiently filled it is carried to the hive, and the honey is deposited in one of the cells.

† Wax generally transpires through the pores of the skin of those insects that produce it, either partially or generally. It is formed from saccharine substances taken into the stomach. In the hive-bee it is produced partially; but in some other insects, as in aphides, and cocci, it is a general transudation from the body. Immense quantities are obtained in China, from an insect, which Sir G. Staunton supposes a species of cicada, and which in its larva state feeds upon a plant like the privit; leaving upon the stem a powder, which, when collected, forms the wax.

wanting the honey when it could not be procured at all, it was farther endued with the no less necessary faculty of constructing repositories for its preservation? Which faculty, it is evident, must depend primarily, upon the capacity of providing suitable materials. Two distinct functions go to make up the ability. First, the power in the bee, with respect to wax, of loading the farina of flowers upon its thighs. Microscopic observers speak of the spoon-shaped appendages with which the thighs of bees are beset for this very purpose; but, inasmuch as the art and will of the bee may be supposed to be concerned in this operation, there is, secondly, that which doth not rest in art or will—a digestive faculty which converts the loose powder into a stiff substance. This is a just account of the honey and the honey-comb; and this account, through every part, carries a creative intelligence along with it.

The *sting* also of the bee has this relation to the honey, that it is necessary for the protection of a treasure which invites so many robbers.

III. Our business is with mechanism. In the *panorpa** tribe of insects, there is a forceps in the tail of the male insect, with which he catches and

* Fig. 3. *Panorpa communis*, (Linn.) is an insect frequently seen in meadows during the early part of summer. It is a long-bodied fly, of moderate size, with four transparent wings, elegantly variegated with deep brown spots. The tail of the male insect, which is usually carried in an upright position, is furnished with a *forceps* somewhat like a lobster's claw.

holds the female. Are a pair of pincers more mechanical than this provision in its structure? or is any structure more clear and certain in its design?

IV. St. Pierre tells us,* that in a fly with six feet (I do not remember that he describes the species,) the pair next the head and the pair next the tail, have brushes at their extremities, with which the fly dresses, as there may be occasion, the anterior or the posterior part of its body; but that the middle pair have no such brushes, the situation of these legs not admitting of the brushes, if they were there, being converted to the same use. This is a very exact mechanical distinction.

V. If the reader, looking to our distributions of science, wish to contemplate the chemistry, as well as the mechanism of nature, the insect creation will afford him an example. I refer to the light in the tail† of a *glow-worm*. Two points seem to be agreed upon by naturalists concerning it: first, that it is phosphoric; secondly, that its use is to attract the male insect. The only thing to be inquired after, is the singularity, if any such there be, in the natural history of this animal, which should render a provision of this kind more necessary for it than for other insects. That singularity seems to be the difference which subsists

* Vol. i. p. 342.

† It is the last two or three segments of the body which emit the light.

between the male and the female; which difference is greater than what we find in any other species of animal whatever. The glow-worm is a female *caterpillar*;* the male of which is a *fly*; lively, comparatively small, dissimilar to the female in appearance, probably also as distinguished from her in habits, pursuits, and manners, as he is unlike in form and external constitution. Here then is the adversity of the case. The caterpillar cannot meet her companion in the air. The winged rover disdains the ground. They might never therefore be brought together, did not this radiant torch direct the volatile mate to his sedentary female.

In this example, we also see the resources of art anticipated. One grand operation of chemistry is the making of phosphorus: and it was thought an ingenious device, to make phosphoric matches supply the place of lighted tapers. Now this very thing is done in the body of the glow-worm. The phosphorus is not only made, but kindled; and caused to emit a steady and genial beam, for the purpose which is here stated, and which I believe to be the true one.†

* Fig. 4. The female glow-worm. Fig. 5. The male of the same insect.

† The phosphorescence of this insect, *lampyris noctiluca*, is most brilliant at the season when the sexes are destined to meet; the design seems evident. In different kinds of luminous insects, however, it may serve a different purpose. Besides the different species of lampyris, another insect of the beetle tribe, *elator noctilucus*, is endowed with the same property, and that in a much higher degree. This fine fly is an inhabitant of some of the West

VI. Nor is the last the only instance that entomology affords, in which our discoveries, or rather our projects, turn out to be imitations of nature. Some years ago, a plan was suggested, of producing propulsion by reaction in this way: by the force of a steam-engine, a stream of water was to be shot out of the stern of a boat; the impulse of which stream upon the water in the river, was to push the boat itself forward; it is, in truth, the principle by which sky-rockets ascend in the air. Of the use or practicability of the plan, I am not speaking; nor is it my concern to praise its ingenuity: but it is certainly a contrivance. Now, if naturalists are to be believed, it is exactly the device which nature has made use of, for the motion

India islands; the light is not emitted except when the insect is flying, at which time the whole body is full of light, of the most beautiful golden-blue lustre, and so considerable that the smallest print may be read by moving the insect over the book. There are not fewer than twelve species of this genus stated to be luminous.

The above are of the order *coleoptera*, but the order *hemiptera* also furnishes a genus called *fulgora*, including several species giving so powerful a light, as to obtain the name of *lantern flies*. Two of the most conspicuous are, *F. candelaria*, and *F. laternaria*: the former a native of America, the latter of China; they have the material which diffuses their light included in a hollow semi-transparent projection of the head. We may easily conceive, as travellers assure us, that a tree studded with multitudes of these living sparks, some at rest and others in motion, must, at night, have a superlatively splendid appearance. In the last-mentioned insects their light is supposed to enable them to discover their prey, and to steer themselves safely by night; so that their enemies are alarmed at these living fires. See an interesting account of luminous insects in Kerby and Spence's Introduction to Entomology, 3rd edit. vol. ii. p. 409.

of some species of aquatic insects. The larva of the *dragon-fly*, according to Adams, swims by ejecting water from its tail; is driven forward by the reaction of water in the pool upon the current issuing in a direction backward from its body.*

VII. Again: Europe has lately been surprised by the elevation of bodies in the air by means of a balloon. The discovery consisted in finding out a manageable substance, which was, bulk for bulk, lighter than air; and the application of the discovery was, to make a body composed of this substance bear up, along with its own weight, some heavier body which was attached to it. This expedient, so new to us, proves to be no other than what the Author of nature has employed in the *gossamer* spider. We frequently see this spider's thread floating in the air, and extended from hedge to hedge, across a road or brook of four or five yards width. The animal which forms the thread has no wings wherewith to fly from one extremity to the other of this line; nor muscles to enable it to spring or dart to so great a distance: yet its Creator hath laid for it a path in the atmos-

* Fig. 6. The larva of some dragon-flies (*æshna* and *libellula*, *F.*) swim by strongly ejecting water from the anus. By first taking in the water and then expelling it, they are enabled to swim. This may be seen by putting one of these larva into a plate with water. We find that while the animal moves forward, a current of water is produced by this pumping in a contrary direction. Sometimes it will raise its tail out of the water, when a stream of water issues from it.

phere; and after this manner. Though the animal itself be heavier than air, the thread which it spins from its bowels is specifically lighter. This is its *balloon*.* The spider, left to itself, would drop to the ground; but being tied to its thread, both are supported. We have here a very peculiar provision: and to a contemplative eye it is a gratifying spectacle, to see this insect wafted on her thread, sustained by a levity not her own, and traversing regions, which, if we examined only the body of the animal, might seem to have been forbidden to its nature.

I must now crave the reader's permission to introduce into this place, for want of a better, an observation or two upon the tribe of animals, whether belonging to land or water, which are covered by *shells*.

I. The *shells* of *snails* are a wonderful, a mechanical, and, if one might so speak concerning

* "Spiders, long before Montgolfier, nay, ever since the creation, have been in the habit of sailing through the fields of ether in these air-light chariots!"

The spider which produces *gossamer* is described by naturalists of the size of a pin's head, the buoyance of whose web carries them about, mounting them in the air, probably in search of food, which consists of effluvia of animal and vegetable substances.

In the autumn the damp air causes the web called gossamer to descend, and it is often seen to cover a whole field to a great extent: and the films are frequently observed, in a fine, clear morning, glittering with drops of dew.

For a curious account of gossamer spiders, see White's Nat. Hist. of Selbourn.

the works of nature, an original contrivance. Other animals have their proper retreats, their hybernacula also, or winter quarters, but the snail carries these about with him. He travels with his tent; and this tent, though, as was necessary, both light and thin, is completely impervious either to moisture or air. The young snail comes out of its egg with the shell upon its back; and the gradual enlargement which the shell receives, is derived from slime excreted by the animal's skin. Now the aptness of this excretion to the purpose, its property of hardening into a shell, and the action, whatever it be, of the animal, whereby it avails itself of its gift, and of the constitution of its glands, (to say nothing of the work being commenced before the animal is born,) are things which can, with no probability, be referred to any other cause than to express design; and that not on the part of the animal alone, in which design, though it might build the house, it could not have supplied the material. The will of the animal could not determine the quality of the excretion. Add to which, that the shell of a snail, with its pillar and convolution, is a very artificial fabric; whilst a snail, as it should seem, is the most numb and unprovided of all artificers. In the midst of variety, there is likewise a regularity, which would hardly be expected. In the same species of snail, the number of turns is usually, if not always, the same. The sealing up of the mouth of the shell

by the snail, is also well calculated for its warmth and security; but the cerate is not of the same substance with the shell.

II. Much of what has been observed of snails belongs to *shell-fish* and their *shells*, particularly to those of the univalve kind; with the addition of two remarks: one of which is upon the great strength and hardness of most of these shells. I do not know whether, the weight being given, art can produce so strong a case as are some of these shells. Which defensive strength suits well with the life of an animal, that has often to sustain the dangers of a stormy element, and a rocky bottom, as well as the attacks of voracious fish. The other remark is, upon the property, in the animal excretion, not only of congealing, but of congealing, or, as a builder would call it, *setting*, in water, and into a cretaceous substance, firm and hard. This property is much more extraordinary, and, chemically speaking, more specific, than that of hardening in the air; which may be reckoned a kind of exsiccation, like the drying of clay into bricks.*

III. In the *bivalve* order of shell-fish, cockles,

* The formation of shells, whether in the testacea or crustacea, is an operation not to be explained on chemical principles, but depends on an animal secretion, whereby a solid matter, chiefly carbonate of lime, is first absorbed, or is taken into the stomach of the animal with its food, and is then separated and deposited by its vessels, according to the laws of its organization. The growth of shells is analogous to the growth of horn, or the hoof of a horse.

muscles, oysters, &c. what contrivance can be so simple or so clear, as the insertion, at the back, of a tough tendinous substance, that becomes at once the ligament which binds the two shells together, and the *hinge* upon which they open and shut.*

IV. The shell of a lobster's tail, in its articulations and overlapping, represents the jointed part of a coat of mail; or rather, which I believe to be the truth, a coat of mail is an imitation of a lobster's shell. The same end is to be answered by both; the same properties, therefore, are required in both, namely, hardness and flexibility, a covering which may guard the part without obstructing its motion. For this double purpose, the art of man, expressly exercised upon the subject, has not been able to devise any thing better than what nature presents to his observation. Is not this, therefore, mechanism, which the mechanic, having a similar purpose in view, adopts? Is the structure of a coat of mail to be referred to art? Is the same structure of the lobster, conducing to the same use, to be referred to any thing less than art?

Some, who may acknowledge the imitation, and assent to the inference which we draw from it in the instance before us, may be disposed, possibly,

* The shells are closed by one or two muscles, according to the shape of the part. In the oyster, and others of a similar form, there is only a single muscle, but of great strength. It is situated near the centre, and firmly fixed to both the shells, and shuts them with great force. The elastic ligament at the hinge acts as an antagonist by opening the shell.

to ask, why such imitations are not more frequent than they are, if it be true, as we allege, that the same principle of intelligence, design, and mechanical contrivance, was exerted in the formation of natural bodies, as we employ in the making of the various instruments by which our purposes are served? The answers to this question are, first, that it seldom happens that precisely the same purpose, and no other, is pursued in any work which we compare, of nature and of art; secondly, that it still more seldom happens, that we *can* imitate nature, if we would. Our materials and our workmanship are equally deficient. Springs and wires, and cork and leather, produce a poor substitute for an arm or a hand. In the example which we have selected, I mean a lobster's shell compared with a coat of mail, these difficulties stand less in the way, than in almost any other that can be assigned; and the consequence is, as we have seen, that art gladly borrows from nature her contrivance, and imitates it closely.

But to return to insects. I think it is in this class of animals above all others, especially when we take in the multitude of species which the microscope discovers, that we are struck with what Cicero has called "the *insatiable* variety of nature." There are said to be six thousand species of flies; seven hundred and sixty butterflies; each different from all the rest. (St. Pierre.) The

same writer tells us, from his own observation, that thirty-seven species of winged insects, with distinctions well expressed, visited a single strawberry-plant in the course of three weeks.* Ray observed, within the compass of a mile or two of his own house, two hundred kinds of butterflies, nocturnal and diurnal. He likewise asserts, but I think without any grounds of exact computation, that the number of species of insects, reckoning all sorts of them, may not be short of ten thousand.† And in this vast variety of animal forms (for the observation is not confined to insects, though more applicable perhaps to them than to any other class) we are sometimes led to take notice of the different methods, or rather of the studiously diversified methods, by which one and the same purpose is attained. In the article of breathing, for example, which was to be provided for in some way or other, besides the ordinary varieties of lungs, gills, and breathing-holes, (for insects in general respire, not by the mouth,‡ but through holes in the sides,) the nymphæ of gnats have an apparatus to raise their *backs* to

* Vol. i. p. 3. † Wisdom of God, p. 23.

‡ Fig. 7. *a, a.* The *spiracula,* or breathing pores of insects, are small orifices in the trunk or abdomen, opening into a canal called the *tracheæ;* by which the air enters the body, or is expelled from it. In the larvæ or caterpillars, a trachea, *b, b,* runs on each side of the body, under the skin, and generally opens externally by nine or ten apertures or spiraculæ; from these the same number of air vessels of a silver colour pass off to be dispersed through the body.

the top of the water, and so take breath.* The hydrocanthari do the like by thrusting their *tails* out of the water.† The maggot of the eruca labra‡ has a long tail, one part sheathed within another, (but which it can draw out at pleasure,) with a starry tuft at the end, by which *tuft*, when expanded upon the surface, the insect both supports itself in the water, and draws in the air which is necessary. In the article of natural clothing, we have the skins of animals invested with scales, hair, feathers, mucus, froth; or itself turned into a shell or crust; in the no less necessary article of offence and defence, we have teeth, talons, beaks, horns, stings, prickles, with (the most singular expedient for the same purpose) the power of giving the electric shock,‖ and, as is cre-

* Fig. 8. The pupa of gnat suspend themselves on the surface of the water, by two auriform respiratory organs on the anterior part of the trunk, their abdomen being then folded under the breast; when disposed to descend the animal unfolds it, and with sudden strokes which she gives with it and her anal swimmers to the water, she swims from right to left, as well as upwards and downwards, with the greatest ease.

† Derham, p. 7.

‡ Fig. 9. This is a well known fly (*stratyonis chamæleon, F.*) chameleon fly, or eruca labra. In its first state it inhabits the water, and often remains supported by its radiated tail, consisting of beautiful feathered hairs or plumes on the surface, with its head downwards. But when it is disposed to seek the bottom or to descend, the radii of the tail is formed into a concavity including in it an air bubble; this is its swim bladder, and by the bending of its body from right to left, contracting itself into the form of the letter S, and then extending itself again into a straight line, it moves itself in any direction.

‖ The *raja torpedo, gymnotus electricus*, and some other fish,

dibly related of some animals, of driving away their pursuers by an intolerable fœtor, or of blackening the water through which they are pursued.* The consideration of these appearances might induce us to believe, that *variety* itself, distinct from every other reason, was a motive in the mind of the Creator, or with the agents of his will.

To this great variety in organized life, the Deity has given, or perhaps there arises out of it, a corresponding variety of animal *appetites*. For the final cause of this we have not far to seek. Did all animals covet the same element, retreat, or food, it is evident how much fewer could be supplied and accommodated, than what at present live conveniently together, and find a plentiful subsistence. What one nature rejects, another delights in. Food which is nauseous to one tribe

have a curious apparatus of nerves, which in its effects may be compared to an electrical battery. In the first-named fish, the electrical organs are situated between the head and the pectoral fins. When the integuments are raised the organ appears, consisting of some hundred pentagonal and hexagonal cells, filled with a glairy fluid. Minute blood-vessels are dispersed over it, and its nerves are of extraordinary size. When the hand is applied to the electrical organs, a benumbing effect is instantly felt in the fingers and the arm. When caught in a net, it has been known to give a violent shock to the hands of the fisherman who ventures to seize it. See Phil. Trans. 1816, p. 120. Ibid. 1817, p. 32.

* The several species of *sepiæ* or *cuttle fish* have this faculty. They possess a bag situated on, or near the liver; called the *ink-bag*, from its containing a black fluid, the contents of which is discharged by a muscular sheath compressing the body of the animal. By this singular evacuation the creature renders the surrounding element so black and bitter, when in danger of being attacked, that an enemy will not pursue it.

of animals, becomes, by that very property which makes it nauseous, an alluring dainty to another tribe. Carrion is a treat to dogs, ravens, vultures, fish. The exhalations of corrupted substances attract flies by crowds. Maggots revel in putrefaction.

CHAPTER XX.

OF PLANTS.

I THINK a designed and studied mechanism to be, in general, more evident in animals than in *plants;* and it is unnecessary to dwell upon a weaker argument, where a stronger is at hand. There are, however, a few observations upon the vegetable kingdom, which lie so directly in our way, that it would be improper to pass by them without notice.

The one great intention of nature in the structure of plants, seems to be the perfecting of the *seed;* and, what is part of the same intention, the preserving of it until it be *perfected.* This intention shows itself, in the first place, by the care which appears to be taken, to protect and ripen, by every advantage which can be given to them of situation in the plant, those parts which most

immediately contribute to fructification, viz. the antheræ, the stamina, and the stigmata. These parts are usually lodged in the centre, the recesses, or the labyrinths of the flower; during their tender and immature state, are shut up in the stalk, or sheltered in the bud: as soon as they have acquired firmness of texture sufficient to bear exposure, and are ready to perform the important office which is assigned to them, they are disclosed to the light and air, by the bursting of the stem, or the expansion of the petals; after which, they have, in many cases, by the very form of the flower during its blow, the light and warmth reflected upon them from the concave side of the cup. What is called also the *sleep** of

* "The periodical change in the direction of leaves, which has been called the "Sleep of Plants," is undeniably connected with the stimulating operation of light. It is established, that during the clear light of the sun, the leaves become erect, and move their upper surface to the light, whilst, on the contrary, during the absence of light, they either hang downwards, and turn to the horizon, or they take an upright position, so that the under surface of the leaves is turned more outward. On account of this particular position of what has been called "Sleeping Plants," we cannot properly ascribe this direction to sleep, because the leaves do sometimes even raise themselves during this state with greater energy; and press upon the stem or leaf-stalk, for the purpose of turning their lower surface outwards. This change is much rather, therefore, the consequence of the contest between the activity of the plant, and the great activity of nature. This change is the more evident, and the sleep of leaves the more striking, the finer and more compounded the organization of the leaves are. We hence most frequently observe it in the pinnated leaves of leguminous plants, although also in some others, as in atriplex.

plants, is the leaves or petals disposing themselves in such a manner as to shelter the young stems, buds, or fruit. They turn up, or they fall down, according as this purpose renders either change of position requisite. In the growth of corn, whenever the plant begins to shoot, the two upper leaves of the stalk join together, embrace the ear, and protect it till the pulp has acquired a certain degree of consistency. In some water-plants, the flowering and fecundation are carried on *within* the stem, which afterwards opens to let loose the impregnated seed.* The *pea*, or papilionaceous tribe, enclose the parts of fructification within a beautiful folding of the internal blossom, sometimes called, from its shape, the boat or keel; itself also protected under a penthouse formed by the external petals. This structure is very artificial; and what adds to the value of it, though it may diminish the curiosity, very general. It has also this further advantage, (and it is an advantage strictly mechanical,) that all the blossoms

That an internal and self-dependent activity is to be taken into account in this sleep of plants, is plain from the fact that this sleep does not equally follow from a short withdrawing of the light, but only from its complete and long continued removal; as also from this other circumstance, that leaves fall asleep or awake at fixed hours, whether the sky be serene or troubled, exactly as happens with regard to animals. Other stimula, too, and especially heat, have a great influence upon this phenomenon, because, in the cold, leaves awaken later, and fall more easily asleep, notwithstanding the influence of light.." Vide Elements of the Philosophy of Plants by Decandolle.

* Philosophical Transactions, part ii. 1796; p. 502.

turn their *backs* to the wind, whenever the gale blows strong enough to endanger the delicate parts upon which the seed depends. I have observed this a hundred times in a field of peas in blossom. It is an aptitude which results from the figure of the flower, and, as we have said, is strictly mechanical; as much so as the turning of a weather-board or tin cap upon the top of a chimney. Of the *poppy*, and of many similar species of flowers, the head, while it is growing, hangs down, a rigid curvature in the upper part of the stem giving to it that position; and in that position it is impenetrable by rain or moisture. When the head has acquired its size, and is ready to open, the stalk *erects* itself, for the purpose, as it should seem, of presenting the flower, and with the flower, the instruments of fructification, to the genial influence of the sun's rays. This always struck me as a curious property; and specifically as well as originally, provided for in the constitution of the plant; for, if the stem be only bent by the weight of the head, how comes it to straighten itself when the head is the heaviest? These instances show the attention of nature to this principal object, the safety and maturation of the parts upon which the seed depends.

In *trees*, especially in those which are natives of colder climates, this point is taken up earlier. Many of these trees (observe in particular the *ash* and the *horse-chesnut*) produce the embryos of the

TAB. XXXIV.

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leaves and flowers in one year, and bring them to perfection the following. There is a winter therefore to be gotten over. Now what we are to remark is, how nature has prepared for the trials and severities of that season. These tender embryos are, in the first place wrapped up with a compactness which no art can imitate; in which state they compose what we call the bud. This is not all. The bud itself is enclosed in scales; which scales are formed from the remains of past leaves, and the rudiments of future ones. Neither is this the whole. In the coldest climates a third preservative is added, by the bud having a *coat* of gum or resin, which, being congealed, resists the strongest frosts. On the approach of warm weather, this gum is softened, and ceases to be a hinderance to the expansion of the leaves and flowers. All this care is part of that system of provisions, which has for its object and consummation the production and perfecting of the seeds.

The SEEDS themselves are packed up in a *capsule*,* a vessel composed of coats, which, compared with the rest of the flower, are strong and tough. From this vessel projects a tube, through which tube the farina, or some subtile fecundating effluvium that issues from it, is admitted to the seed. And here also occurs a mechanical variety, ac-

* TAB. XXXIV. Fig. 1. The *capsule* or seed vessel of the poppy: (*papaver somniferum:*) it is divided to exhibit its internal structure.

commodated to the different circumstances under which the same purpose is to be accomplished. In flowers which are erect, the pistil is shorter than the stamina; and the pollen, shed from the antheræ into the cup of the flower, is caught in its descent by the head of the pistil, called the stigma.* But how is this managed when the flowers hang down, (as does the crown-imperial for instance,) and in which position the farina, in its fall, would be carried from the stigma, and not towards it? The relative length of the parts is now inverted.† The pistil in these flowers is usually longer instead of shorter than the stamina, that its protruding summit may receive the pollen as it drops to the ground. In some cases (as in the *nigella*,‡) where the shafts of the pistils or styles are disproportionably long, they bend down their extremities upon the antheræ, that the necessary approximation may be effected.‖

* Fig. 2. is an instance of this kind in a flower of the agave Americana; *a*, the *pistil*; *b*, the *stigma*; *c*, the *stamina*; *d*, the *antheræ*.

† Fig. 3. A flower of the *crown-imperial*; *a*, the *pistil*; *b*. the *stamina*.

‡ Fig. 4. A blossom of the *nigella*.

‖ Amongst the various means which nature has provided for the purpose of assisting the impregnation of plants, that afforded by the agency of insects is not one of the least. In the spring and summer months numerous species of these lively little beings may be seen in almost every expanded flower; and whether they are in search of honey, which is contained in the nectaries of many flowers, or whatever may be the object of their attraction, by being continually on the move, they, no doubt, further the dispersion of

But (to pursue this great work in its progress) the impregnation, to which all this machinery relates, being completed, the other parts of the flower fade and drop off, whilst the *gravid-seed vessel*, on

the pollen, and thus, in a great measure, contribute to the fertility of the plants they visit.

In many plants, as those which belong to the Linnæan class *diœcia*, where the stamens and pistils are in separate flowers, and those flowers situated on two separate plants of the same species, the operation of insects, or the efficacy of winds, is indispensably necessary to the perfecting the fruit, by transporting the pollen of the one to the stigma of the other.

Some plants, indeed, that have perfect, or united flowers, have the anthers so situated that it is almost impossible the pollen can, of itself, reach the stigma; in this case insects generally become the auxiliaries to the fertilization of the seed. An instance of this may be seen in the *aristolochia clematitis*. "According to Professor Willdenow, the flower of this plant is so formed, that the anthers of themselves cannot impregnate the stigma; but this important affair is devolved upon a particular species of *tipula*, (*T. pennicornis*.) The throat of the flower is lined with dense hair, pointing downward so as to form a kind of funnel, or entrance like that of some kinds of mouse-traps, through which the insects may easily enter but not return: several creep in, and, uneasy at their confinement, are constantly moving to and fro, and so deposit the pollen upon the stigma: but when the work intrusted to them is completed, and impregnation has taken place, the hair which prevented their escape shrinks, and adheres closely to the sides of the flower, and these little go-betweens of Flora at length leave their prison. A writer, however, in the Annual Medical Review (ii. 400.) doubts the accuracy of this fact, on the ground that he could never find *T. pennicornis*, though *A clematitis* has produced fruit two years at Brompton." Introduction to Entomology by Kirby and Spence, vol. i. p. 298.

That the *tipula pennicornis* does enter the flowers of *aristolochia clematitis*, as recorded by Professor Willdenow, I can confidently affirm, from having observed them in great plenty in the inflated base of the coralla every year, for these last fifteen years, in the Oxford Botanic Garden, where the plant generally

the contrary, proceeds to increase its bulk, always to a great, and in some species (in the gourd, for example, and melon,) to a surprising comparative size; assuming in different plants an incalculable variety of forms, but all evidently conducing to the security of the seed. By virtue of this process, so necessary but so diversified, we have the seed at length, in stone fruits and nuts, incased in a strong shell, the shell itself enclosed in a pulp or husk, by which the seed within is, or hath been, fed; or, more generally, (as in grapes, oranges, and the numerous kinds of berries,) plunged over-head in a glutinous syrup, contained within a skin or bladder: at other times (as in apples and pears) embedded in the heart of a firm fleshy substance; or (as in strawberries) pricked into the surface of a soft pulp.

These and many more varieties exist in what we call *fruits*.* In pulse, and grain, and grasses;

forms fruit. The first time I found this insect in the flowers of the above species of *aristolochia*, was, on the 12th of July, 1812, at Godstow, near Oxford, where the plant was then growing in a wild state near the ruins of the nunnery.

For the above observations the editor is indebted to an excellent botanist, Mr. W. Baxter.

* From the conformation of fruits alone, one might be led, even without experience, to suppose, that part of this provision was destined for the utilities of animals. As limited to the plant, the provision itself seems to go beyond its object. The flesh of an apple, the pulp of an orange, the meat of a plum, the fatness of the olive, appear to be *more* than sufficient for the nourishing of the seed or kernel. The event shows, that this redundancy, if it be one, ministers to the support and gratification of animal

in trees, and shrubs, and flowers; the variety of the seed-vessels is incomputable. We have the seeds (as in the pea tribe) regularly disposed in parchment pods, which, though soft and membranous, completely exclude the wet, even in the heaviest rains! the pod also, not seldom (as in the bean) lined with a fine down; at other times (as in the senna) distended like a blown bladder: or we have the seed enveloped in wool (as in the cotton plant,) lodged (as in pines) between the hard and compact scales of a cone, or barricaded (as in the artichoke and thistle) with spikes and prickles;

natures; and when we observe a provision to be more than sufficient for one purpose, yet wanted for another purpose, it is not unfair to conclude, that both purposes were contemplated together. It favours this view of the subject to remark, that fruits are not (which they might have been) ready altogether, but that they ripen in succession throughout a great part of the year; some in summer; some in autumn: that some require the slow maturation of the winter, and supply the spring; also that the coldest fruits grow in the hottest places. Cucumbers, pine-apples, melons, are the natural produce of warm climates, and contribute greatly, by their coolness, to the refreshment of the inhabitants of those countries.

I will add to this note the following observation communicated to me by Mr. Brinkley: (PALEY.)

"The eatable part of the cherry or peach first serve the purposes of perfecting the seed or kernel, by means of vessels passing through the stone, and which are very visible in a peach-stone. After the kernel is perfected, the stone becomes hard, and the vessels cease their functions. But the substance surrounding the stone is not then thrown away as useless. That which was before only an instrument for perfecting the kernel now receives and retains to itself the whole of the sun's influence, and thereby becomes a grateful food to man. Also, what an evident mark of design is the stone protecting the kernel! The intervention of the stone prevents the second use from interfering with the first."

in mushrooms, placed under a penthouse; in ferns, within slits in the back part of the leaf; or (which is the most general organization of all) we find them covered by strong, close tunicles, and attached to the stem according to an order appropriated to each plant, as is seen in the several kinds of grains and of grasses.

In which enumeration, what we have first to notice is, unity of purpose under variety of expedients. Nothing can be more *single* than the design; more *diversified* than the means. Pellicles, shells, pulps, pods, husks, skin, scales, armed with thorns, are all employed in prosecuting the same intention. Secondly; we may observe, that, in all these cases, the purpose is fulfilled within a just and *limited* degree. We can perceive, that if the seeds of plants were more strongly guarded than they are, their greater security would interfere with other uses. Many species of animals would suffer, and many perish, if they could not obtain access to them. The plant would overrun the soil; or the seed be wasted for want of room to sow itself. It is sometimes as necessary to destroy particular species of plants, as it is at other times to encourage their growth. Here, as in many cases, a balance is to be maintained between opposite uses. The provisions for the preservation of seeds appear to be directed, chiefly, against the inconstancy of the elements, or the sweeping destruction of inclement seasons. The depredation of

animals, and the injuries of accidental violence, are allowed for in the abundance of the increase. The result is, that out of the many thousand different plants which cover the earth, not a single species, perhaps, has been lost since the creation.

When nature has perfected her seeds, her next care is to disperse them. The seed cannot answer its purpose while it remains confined in the capsule. After the seeds therefore are ripened, the pericarpium opens to let them out: and the opening is not like an accidental bursting, but, for the most part, is according to a certain rule in each plant. What I have always thought very extraordinary; nuts and shells, which we can hardly crack with our teeth, divide and make way for the little tender sprout which proceeds from the kernel. Handling the nut, I could hardly conceive how the plantule was ever to get out of it. There are cases, it is said, in which the seed-vessel, by an elastic jerk at the moment of its explosion, casts the seeds to a distance.* We all

* This mode of the dispersion of seeds is exemplified in the common furze, *ulex Europæus*; in most species of *euphorbia*, or spurge, and in fraxinella, *dictamnus albus*.

Many species of *pines* discharge their seeds by the opening of the scales of their cones, in hot sunny weather, with a sudden jerk, which is accompanied by a crackling noise: and when a number of these cones happen to burst together, the noise is said to be heard at some considerable distance. The Rev. P. Keith, in his excellent System of Physiological Botany, vol. ii. p. 399, informs us, that this crackling noise was observed and traced to a

however know, that many seeds (those of most composite flowers, as of the thistle, dandelion, &c.) are endowed with what are most improperly called *wings;* that is, downy appendages, by which they are enabled to float in the air, and are carried oftentimes by the wind to great distances from the plant which produces them. It is the swelling also of this downy tuft within the seed-vessel, that seems to overcome the resistance of its coats, and to open a passage for the seed to escape.

But the *constitution* of seeds is still more admirable than either their preservation or their dispersion. In the body of the seed of every species of plant, or nearly of every one, provision is made for two grand purposes; first, for the safety of the *germ;* secondly, for the temporary support of the future plant. The sprout, as folded up in the seed,

fir-tree, namely *pinus pinea*, at Rendlesham Parsonage, on July 14, 1808, by two young gentlemen, his pupils, who thought the tree was bewitched, till the cause of the noise was pointed out to them.

If the seed-vessel of the touch-me-not, *impatiens noli-me-tangere*, which is composed of five valves and five cells, be touched ever so slightly, when quite ripe, it immediately bursts open, and the valves, separating elastically, and coiling themselves up in a spiral form, discharge the seeds with considerable force, and thus scatter them in all directions around the parent plant.

Some species of *cardamine* or cuckoo flower discharge their seed in a similar manner, especially *cardamine impatiens*. The least pressure on the summit of the seed-vessel, or *siliqua*, of this species, when it is ripe, will disengage the two valves, which immediately, and with an elastic spring, roll themselves up from the base to the summit, at the same time ejecting the seed with violence and throwing it around to some distance.—Baxter.

is delicate and brittle beyond any other substance. It cannot be touched without being broken. Yet, in beans, peas, grass-seeds, grain, fruits, it is so fenced on all sides, so shut up and protected, that, whilst the seed itself is rudely handled, tossed into sacks, shovelled into heaps, the sacred particle, the miniature plant, remains unhurt. It is wonderful also, how long many kinds of seeds, by the help of their integuments, and perhaps of their oils, stand out against decay. A grain of mustard seed has been known to lie in the earth for a hundred years; and, as soon as it hath acquired a favourable situation, to shoot as vigorously as if just gathered from the plant. Then, as to the second point, the temporary support of the future plant, the matter stands thus. In grain, and pulse, and kernels, and pippins, the germ composes a very small part of the seed. The rest consists of a nutritious substance, from which the sprout draws its aliment for some considerable time after it is put forth; viz. until the fibres, shot out from the other end of the seed, are able to imbibe juices from the earth, in a sufficient quantity for its demand. It is owing to this constitution, that we see seeds sprout, and the sprouts make a considerable progress without any earth at all. It is an economy also, in which we remark a close analogy between the seeds of plants, and the eggs of animals. The same point is provided for, in the same manner, in both. In the egg, the residence

of the living principle, the cicatrix, forms a very minute part of the contents. The white and the white only is expended in the formation of the chicken. The yolk, very little altered or diminished, is wrapped up in the abdomen of the young birds when it quits the shell, and serves for its nourishment, till it have learnt to pick its own food. This perfectly resembles the first nutrition of a plant. In the plant, as well as in the animal, the structure has every character of contrivance belonging to it: in both, it breaks the transition from prepared to unprepared aliment; in both, it is prospective and compensatory. In animals which suck, this intermediate nourishment is supplied by a different source.

In all subjects, the most common observations are the best, when it is their truth and strength which have made them common. There are, of this sort, *two* concerning plants, which it falls within our plan to notice. The *first* relates to what has already been touched upon, their germination. When a grain of corn is cast into the ground, this is the change which takes place. From one end of the grain issues a green sprout; from the other, a number of white fibrous threads. How can this be explained? Why not sprouts from both ends? why not fibrous threads from both ends?* To what is the difference to be

* Fig 5. A grain of barley, shewing the *plumule* and *radicle growing from it.*

referred, but to design; to the different uses which the parts are thereafter to serve; uses which discover themselves in the sequel of the process? The sprout, or plumule, struggles into the air; and becomes the plant, of which, from the first, it contained the rudiments: the fibres shoot into the earth; and thereby both fix the plant to the ground, and collect nourishment from the soil for its support.* Now, what is not a little remarkable,

* "The *seed*, the last production of vigorous vegetation, is wonderfully diversified in form. Being of the highest importance to the resources of nature, it is defended above all other parts of the plant, by soft, pulpy substances; as in the esculent fruits, by thick membranes, as in the leguminous vegetables, and by hard shells, or a thick epidermis, as in the palms and grasses.

"In every seed there is to be distinguished, first, the *organ of nourishment;* secondly, the nascent plant, or the *plume;* thirdly, the nascent root, or the *radicle.*

"In the common garden bean, the organ of nourishment is divided into two lobes called *cotyledons;* the plume is the small white point between the upper part of the lobes; and the radicle is the small curved cone at their base.

"In wheat, and in many of the grasses, the organ of nourishment is a single part, and these plants are called *monocotyledonous.* In other cases it consists of more than two parts, when the plants are called *polycotyledonous.* In the greater number of instances it is, however, simply divided into two, and is *dicotyledonous.*

"The matter of the seed, when examined in its common state, appears dead and inert; it exhibits neither the forms nor the functions of life. But let it be acted upon by moisture, heat, and air, and its organized powers are soon distinctly developed. The cotyledons expand, the membranes burst, the radicle acquires new matter, descends into the soil, and the plume rises towards the free air. By degrees, the organs of nourishment of dicotyledonous plants become vascular, and are converted into seed leaves, and the perfect plant appears above the soil. Nature has provided the elements of germination on every part of the surface; water and pure air and heat are universally active, and the means for the

the parts issuing from the seed take their respective directions, into whatever position the seed itself happens to be cast. If the seed be thrown into the wrongest possible position, that is, if the ends point in the ground the reverse of what they ought to do, every thing, nevertheless, goes on right. The sprout, after being pushed down a little way, makes a bend, and turns upwards; the fibres, on the contrary, after shooting at first upwards, turn down. Of this extraordinary vegetable fact, an account has lately been attempted to be given: "The plumule (it is said) is stimulated by the *air* into action, and elongates itself when it is thus most excited; the radicle is stimulated by *moisture*, and elongates itself when *it* is thus most excited. Whence one of these grows upward in quest of its adapted object, and the other downward."* Were this account better verified by experiment† than it is, it only shifts the contriv-

preservation and multiplication of life, are at once simple and grand." See Sir H. Davy's Elements of Agricultural Chemistry, edit. 2. p. 70.

* Darwin's Phytologia, p. 144.

† "Gravitation has a very important influence on the growth of plants; and it is rendered probable, by the experiments of Mr. Knight, that they owe the peculiar direction of their roots and branches almost entirely to its force.

"That gentleman fixed some seeds of the garden bean on the circumference of a wheel, which in one instance was placed vertically, and in the other horizontally, and made to revolve, by means of another wheel worked by water, in such a manner, that the number of the revolutions could be regulated; the beans were supplied with moisture, and were placed under circumstances favourable to germination. The great velocity of motion given

ance. It does not disprove the contrivance; it only removes it a little farther back. Who, to use our author's own language, "*adapted* the objects?" Who gave such a quality to these connate

to the wheel was such, that it performed two hundred and fifty revolutions in a minute. It was found that in all cases the beans grew, and that the direction of the roots and stems was influenced by the motion of the wheel. When the centrifugal force was made superior to the force of gravitation, which was supposed to be done when the vertical wheel performed one hundred and fifty revolutions in a minute, all the radicles, in whatever way they were protruded from the position of the seeds, turned their points outwards from the circumference of the wheel, and in their subsequent growth receded nearly at right angles from its axis; the germens (plumules) on the contrary, took the opposite direction, and in a few days their points all met in the centre of the wheel.

"When the centrifugal force was made merely to modify the force of gravitation in the horizontal wheel, where the greatest velocity of revolution was given, the radicles pointed downwards about ten degrees below, and the germens (plumules) as many degrees above the horizontal line of the wheel's motion; and the deviation from the perpendicular was less in proportion, as the motion was less rapid.

"These facts afford a rational solution of this curious problem, respecting which different philosophers have given such different opinions; some referring it to the nature of the sap, as De la Hire, others, as Darwin, to the living powers of the plant, and the stimulus of air upon the leaves, and of moisture upon the roots. The effect is now shewn to be connected with mechanical causes; and there seems no other power in nature to which it can with propriety be referred but gravity, which acts universally, and which must tend to dispose the parts to take a uniform direction.

"The direction of the radicles and germens (plumules) is such, that both are supplied with food, and acted upon by those external agents which are necessary for their developement and growth. The roots come in contact with the fluids in the ground; the leaves are exposed to light and air; and the same grand law which preserves the planets in their orbits is thus essential to the functions of vegetable life." See Sir H. Davy's Elements of Agricultural Chemistry, edit. 2. p. 32.

parts, as to be susceptible of *different* "stimulation;" as to be "excited" each only by its own element, and precisely by that which the success of the vegetation requires? I say, "which the success of the vegetation requires:" for the toil of the husbandman would have been in vain; his laborious and expensive preparation of the ground in vain; if the event must, after all, depend upon the position in which the scattered seed was sown. Not one seed out of a hundred would fall in a right direction.

Our *second* observation is upon a general property of climbing plants, which is strictly mechanical. In these plants, from each knot or joint, or as botanists call it, axilla, of the plant, issue, close to each other, two shoots; one bearing the flower and fruit; the other, drawn out into a wire, a long, tapering, spiral tendril, that twists itself round any thing which lies within its reach. Considering, that in this class two purposes are to be provided for, (and together,) fructification and support, the fruitage of the plant, and the sustentation of the stalk, what means could be used more effectual, or, as I have said, more mechanical, than what this structure presents to our eyes? Why, or how, without a view to this double purpose, do two shoots, of such different and appropriate forms, spring from the same joint, from contiguous points of the same stalk? It never happens thus in robust plants, or in trees. "We

see not (says Ray) so much as one tree, or shrub, or herb, that hath a firm and strong stem, and that is able to mount up and stand alone without assistance, *furnished with these tendrils.*" Make only so simple a comparison as that between a pea and a bean. Why does the pea put forth tendrils, the bean not; but because the stalk of the pea cannot support itself, the stalk of the bean can? We may add also, as a circumstance not to be overlooked, that in the pea tribe these clasps do not make their appearance till they are wanted; till the plant has grown to a height to stand in need of support.

This word "support" suggests to us a reflection upon a property of grasses, of corn, and canes. The hollow stems of these classes of plants are set, at certain intervals, with joints. These joints are not found in the trunks of trees, or in the solid stalks of plants. There may be other uses of these joints; but the fact is, and it appears to be at least one purpose designed by them, that they *corroborate* the stem; which, by its length and hollowness, would otherwise be too liable to break or bend.*

* Plants are not only supplied with various appendages for procuring support to the weaker species: "The *stipulæ* protect the nascent leaves; and the *bracteæ* perform a similar office to the blossom. The different kinds of hairs of down, of thorns, and prickles, which are found on the surface of different plants, have various uses, some of which are easily understood, particularly that defending the plant from molestation by animals. The sting of the

Grasses are Nature's care. With these she clothes the earth; with these she sustains its inhabitants. Cattle feed upon their leaves; birds upon their smaller seeds; men upon the larger; for few readers need be told, that the plants which produce our bread-corn, belong to this class. In those tribes, which are more generally considered as grasses, their extraordinary means and powers of preservation and increase, their hardiness, their almost unconquerable disposition to spread, their faculties of reviviscence, coincide with the intention of nature concerning them. They thrive under a treatment by which other plants are destroyed. The more their leaves are consumed, the more their roots increase. The more they are trampled upon, the thicker they grow. Many of the seemingly dry and dead leaves of grasses revive, and renew their verdure in the spring. In lofty mountains, where the summer heats are not sufficient to ripen the seeds, grasses abound, which are viviparous, consequently able to propagate themselves without seed. It is an observation,

nettle is of this class; and its structure bears a striking analogy to that of the poisonous fangs of serpents. The purposes answered by the down which covers a great number of plants, are not very obvious. It perhaps serves as a protection from the injurious effects of cold winds on the tender surface: or it may have a relation to the deposition of moisture; or, as it may be farther conjectured, the number of points which are presented to the air may be designed to convey electricity from the atmosphere, or to restore the electric equilibrium which may have been disturbed by the process of vegetation." Dr. Roget's Bridgewater Treatise, p. 94.

likewise, which has often been made, that herbivorous animals attach themselves to the leaves of grasses; and, if at liberty in their pastures to range and choose, leave untouched the straws which support the flowers.*

The GENERAL properties of vegetable nature, or properties common to large portions of that kingdom, are almost all which the compass of our argument allows to bring forward. It is impossible to follow plants into their several species. We may be allowed, however, to single out three or four of these species as worthy of a particular notice, either by some singular mechanism, or by some peculiar provision, or by both.

I. In Dr. Darwin's Botanic Garden (1. 395, note,) is the following account of the *vallisneria*, as it has been observed in the river Rhone.— "They have roots at the bottom of the Rhone. The flowers of the *female plant* float on the surface of the water, and are furnished with an *elastic spiral stalk*, which extends or contracts as the water rises or falls; this rise or fall, from the torrents which flow into the river, often amounting to many feet in a few hours. The flowers of the *male plant* are produced under water; and as soon as the fecundating farina is mature, they separate themselves from the plant, rise to the surface, and are wafted by the air, or borne by the

* Withering's Botanical Arrangement, vol. i. p. 28. edit. 2.

currents, to the female flowers."* Our attention in this narrative will be directed to two particulars; first to the mechanism, the "elastic spiral stalk," which lengthens or contracts itself according as the water rises or falls; secondly, to the provision which is made for bringing the male flower, which is produced *under* water, to the female flower which floats upon the surface.

II. My second example I take from Withering's Arrangement, vol. ii. p. 209. ed. 3. "The *cuscuta Europæa* is a parasitical plant.† The seed opens and puts forth a *little spiral body*, which does NOT seek the earth to take root, but *climbs* in a spiral direction, from right to left, up other plants, from which, by means of vessels, it draws its nourishment." The "little spiral body" proceeding from the seed, is to be compared with the fibres which seeds send out in ordinary cases: and

* TAB. XXXV. *Vallisneria spiralis.* Fig. 1. the *female plant*, the flowers of which are purple. Fig. 2. the *male plant*, producing white flowers; these when mature rise like air bubbles, and suddenly expanding when they reach the surface of the water, float about in such abundance as to cover it entirely. "Thus their pollen is scattered over the stigmas of the first mentioned blossoms, whose stalks soon afterwards resume their spiral figure, and the fruit comes to maturity at the bottom of the water." Fig. 3. one of the separated *male* flowers magnified.

† TAB. XXXVI. "Of all the parasitical plants, the dodder (cuscuta) tribe are the most singular, trusting for their nourishment entirely to those vegetables about which they twine, and into whose tender bark they insert small villous tubercles serving as roots, the original root of the dodder withering away entirely as soon as the young stem has fixed itself to any other plant; so that its connexion with the earth is cut off." English Botany, p. 55.

2

3

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TAB. XXXVI.

the comparison ought to regard both the form of the threads and the direction. They are straight; this is spiral. They shoot downwards; this points upwards. In the rule, and in the exception, we equally perceive design.

III. A better known parasitical plant is the ever-green shrub, called the *mistletoe.* What we have to remark in it, is a singular instance of *compensation.*

No art hath yet made these plants take root in the earth. Here therefore might seem to be a mortal defect in their constitution. Let us examine how this defect is made up to them. The seeds are endued with an adhesive quality, so tenacious, that, if they be rubbed upon the smooth bark of almost any tree, they will stick to it. And then what follows? Roots springing from these seeds insinuate their fibres into the woody substance of the tree; and the event is, that a mistletoe plant is produced next winter.* Of no other plant do the roots refuse to shoot in the ground; of no other plant do the seeds possess this adhesive, generative quality, when applied to the bark of trees.

IV. Another instance of the *compensatory* system is in the autumnal crocus, or meadow saffron (*colchicum autumnale.*)† I have pitied this poor

* Withering's Botanical Arrangement, vol. i. p. 203. edit. 2.

† Tab. XXXVII. The *colchicum autumnale.* This plant before us exhibits a mode of fructification scarcely paralleled among

plant a thousand times. Its blossom rises out of the ground in the most forlorn condition possible; without a sheath, a fence, a calyx, or even a leaf to protect it; and that, not in the spring, not to be visited by summer suns, but under all the disadvantages of the declining year. When we come, however, to look more closely into the structure of this plant, we find that, instead of its being neglected, Nature has gone out of her course to provide for its security, and to make up to it for all its defects. The seed-vessel, which in other plants is situated within the cup of the flower, or just beneath it, in this plant lies buried ten or twelve inches under ground within the bulbous root. The tube of the flower, which is seldom more than a few tenths of an inch long, in this plant extends down to the root. The stiles in all cases reach the seed-vessel; but it is in this, by an elongation unknown to any other plant. All these singularities contribute to one end. "As this plant blossoms late in the year, and probably would not have time to ripen its seeds before the access of winter, which would destroy them, Pro-

British vegetables. The flowers appearing very late in autumn, the impregnated germen remains latent under ground close to the bulb till the following spring, when the capsule rises above the surface accompanied by several long upright leaves, and the seeds are ripened about June, after which the leaves decay. See British Botany, vol. i. p. 133. The plant is represented as it appears in *spring;* the root is divided to shew the *seed-vessel* near the bulb. The flower is remarkable for the length of its tube.

TAB. XXXVII.

vidence has contrived its structure such, that this important office may be performed at a depth in the earth out of reach of the usual effects of frost."* That is to say, in the autumn nothing is done above ground but the business of impregnation; which is an affair between the antheræ and the stigmata, and is probably soon over. The maturation of the impregnated seed, which in other plants proceeds within a capsule, exposed together with the rest of the flower to the open air, is here carried on, and during the whole winter, within the heart, as we may say, of the earth, that is "out of the reach of the usual effects of frost." But then a new difficulty presents itself. Seeds, though perfected, are known not to vegetate at this depth in the earth. Our seeds, therefore, though so safely lodged, would, after all, be lost to the purpose for which all seeds are intended. Lest this should be the case, "a second admirable provision is made to raise them above the surface when they are perfected, and to sow them at a proper distance;" viz. the germ grows up *in the spring*, upon a fruit-stalk, accompanied with leaves. The seeds now, in common with those of other plants, have the benefit of the summer, and are sown upon the surface. The order of vegetation externally is this:—the plant produces its flowers in September; its leaves and fruits in the spring following.

* Withering's Botanical Arrangement, p. 360.

V. I give the account of the *dionæa muscipula*, an extraordinary American plant, as some late authors have related it; but whether we be yet enough acquainted with the plant, to bring every part of this account to the test of repeated and familiar observation, I am unable to say. "Its leaves are jointed, and furnished with two rows of strong prickles; their surfaces covered with a number of minute glands, which secrete a sweet liquor that allures the approach of flies. When these parts are touched by the legs of flies, the two lobes of the leaf instantly spring up, the rows of prickles lock themselves fast together, and squeeze the unwary animal to death."* Here, under a new model, we recognize the ancient plan of nature, viz. the relation of parts and provisions to one another, to a common office, and to the utility of the organized body to which they belong.† The attracting syrup, the rows of strong

* Smellie's Philosophy of Natural History, vol. i. p. 5.

† Tab. XXXVIII. The *dionæa muscipula*, or Venus's fly-trap. Some parts of this plant are so remarkable as to deserve a more particular description. It is a native of North Carolina; the root perennial; leaves all radical, supported on long fleshy and strongly veined footstalks, leaving a small portion of this next the leaf naked: the leaf itself consists of two semi-oval lobes jointed at the back, so as to allow them to fold close together; they are fleshy, and when viewed through a lense glandular, sometimes of a reddish colour on the upper surface; the sides of both lobes are furnished with a row of cartilaginous ciliæ which stand nearly at right angles with the surface of the leaf, and lock into each other when they close. Near the middle of each lobe are three small spines, which are supposed to assist in destroying the entrapped

prickles, their position so as to interlock the joints of the leaves; and what is more than the rest, that singular irritability of their surfaces, by which they close at a touch; all bear a contributory part in producing an effect, connected either with the defence or with the nutrition of the plant.

CHAPTER XXI.

THE ELEMENTS.

When we come to the elements, we take leave of our mechanics; because we come to those things, of the organization of which, if they be organized, we are confessedly ignorant. This ignorance is implied by their name. To say the truth, our investigations are stopped long before we arrive at this point. But then it is for our comfort to find, that a knowledge of the constitution of the elements is not necessary for us. For instance, as Addison has well observed, "we know *water* sufficiently, when we know how to boil, how

insect. In warm weather the lobes are fully expanded and highly irritable, and if a fly or other insect at this time light upon them they suddenly close, and the poor animal is imprisoned till it dies. See Curtis's Botanical Magazine, No. 785.

to freeze, how to evaporate, how to make it fresh, how to make it run or spout out in what quantity and direction we please, without knowing what water is." The observation of this excellent writer has more propriety in it now, than it had at the time it was made: for the constitution, and the constituent parts of water, appear in some measure to have been lately discovered; yet it does not, I think, appear, that we can make any better or greater use of water since the discovery, than we did before it.

We can never think of the elements without reflecting upon the number of distinct uses which are *consolidated* in the same substance. The *air* supplies the lungs, supports fire, conveys sound, reflects light, diffuses smells, gives rain, wafts ships, bears up birds. Ἐξ ὑδατος τα παντα: *water*, besides maintaining its own inhabitants, is the universal nourisher of plants, and through them of terrestrial animals; is the basis of their juices and fluids; dilutes their food; quenches their thirst; floats their burdens. *Fire* warms, dissolves, enlightens; is the great promoter of vegetation and life, if not necessary to the support of both.

We might enlarge, to almost any length we pleased, upon each of these uses; but it appears to me almost sufficient to state them. The few remarks which I judge it necessary to add, are as follow:

I. *Air* is essentially different from earth. There

appears to be no necessity for an atmosphere's investing our globe; yet it does invest it: and we see how many, how various, and how important are the purposes which it answers to every order of animated, not to say of organized beings, which are placed upon the terrestrial surface. I think that every one of these uses will be understood upon the first mention of them, except it be that of *reflecting* light, which may be explained thus:— If I had the power of seeing only by means of rays coming directly from the sun, whenever I turn my back upon the luminary, I should find myself in darkness. If I had the power of seeing by reflected light, yet by means only of light reflected from solid masses, these masses would shine, indeed, and glisten, but it would be in the dark. The hemisphere, the sky, the world, could only be *illuminated*, as it is illuminated, by the light of the sun being from all sides, and in every direction, reflected to the eye, by particles, as numerous, as thickly scattered, and as widely diffused, as are those of the air.

Another general quality of the atmosphere is the power of evaporating fluids. The adjustment of this quality to our use is seen in its action upon the sea. In the sea, water and salt are mixed together most intimately; yet the atmosphere raises the water, and leaves the salt. Pure and fresh as drops of rain descend, they are collected from brine. If evaporation be solution, (which

seems to be probable,) then the air dissolves the water, and not the salt. Upon whatever it be founded, the distinction is critical; so much so, that when we attempt to imitate the process by art, we must regulate our distillation with great care and nicety, or, together with the water, we get the bitterness, or, at least, the distastefulness, of the marine substance: and, after all, it is owing to this original elective power in the air, that we can effect the separation which we wish, by any art or means whatever.

By evaporation, water is carried up into the air; by the converse of evaporation, it falls down upon the earth. And how does it fall? Not by the clouds being all at once re-converted into water, and descending like a sheet; not in rushing down in columns from a spout; but in moderate drops, as from a colander. Our watering-pots are made to imitate showers of rain. Yet *a priori*, I should have thought either of the two former methods more likely to have taken place than the last.

By respiration, flame, putrefaction, air is rendered unfit for the support of animal life. By the constant operation of these corrupting principles, the whole atmosphere, if there were no restoring causes, would come at length to be deprived of its necessary degree of purity. Some of these causes seem to have been discovered, and their efficacy ascertained by experiment. And so far as the discovery has proceeded, it opens to us a beautiful

and a wonderful economy. *Vegetation* proves to be one of them. A sprig of mint corked up with a small portion of foul air placed in the light, renders it again capable of supporting life or flame. Here, therefore, is a constant circulation of benefits maintained between the two great provinces of organized nature. The plant purifies what the animal has poisoned; in return, the contaminated air is more than ordinarily nutritious to the plant. *Agitation with water* turns out to be another of these restoratives. The foulest air, shaken in a bottle with water for a sufficient length of time, recovers a great degree of its purity. Here then again, allowing for the scale upon which nature works, we see the salutary effects of *storms* and *tempests*. The yesty waves which confound the heaven and sea, are doing the very thing which was done in the bottle. Nothing can be of greater importance to the living creation, than the salubrity of their atmosphere. It ought to reconcile us, therefore, to these agitations of the elements, of which we sometimes deplore the consequences, to know, that they tend powerfully to restore to the air that purity, which so many causes are constantly impairing.

II. In water, what ought not a little to be admired, are those negative qualities which constitute its *purity*. Had it been vinous, or oleaginous, or acid; had the sea been filled, or the rivers flowed, with wine or milk; fish constituted as they are,

must have died; plants, constituted as they are, would have withered; the lives of animals which feed upon plants, must have perished. Its very *insipidity*, which is one of those negative qualities, renders it the best of all menstrua. Having no taste of its own, it becomes the sincere vehicle of every other. Had there been a taste in water, be it what it might, it would have infected every thing we ate or drank, with an importunate repetition of the same flavour.

Another thing in this element, not less to be admired, is the constant *round* which it travels; and by which, without suffering either adulteration or waste, it is continually offering itself to the wants of the habitable globe. From the sea are exhaled those vapours which form the clouds; these clouds descend in showers, which, penetrating into the crevices of the hills, supply springs; which springs flow in little streams into the valleys; and there, uniting, become rivers; which rivers, in return, feed the ocean. So there is an incessant circulation of the same fluid; and not one drop probably more or less now than there was at the creation. A particle of water takes its departure from the surface of the sea, in order to fulfil certain important offices to the earth; and, having executed the service which was assigned to it, returns to the bosom which it left.

Some have thought, that we have too much water upon the globe, the sea occupying above

three quarters of its whole surface. But the expanse of ocean, immense as it is, may be no more than sufficient to fertilize the earth. Or independently of this reason, I know not why the sea may not have us good a right to its place as the land. It may proportionably support as many inhabitants; minister to as large an aggregate of enjoyment. The land only affords a habitable surface; the sea is habitable to a great depth.

III. Of fire, we have said that it *dissolves*. The only idea probably which this term raised in the reader's mind, was that of fire melting metals, resins, and some other substances, fluxing ores, running glass, and assisting us in many of our operations, chemical or culinary. Now these are only uses of an occasional kind, and give us a very imperfect notion of what fire does for us. The grand importance of this dissolving power, the great office indeed of fire in the economy of nature, is keeping things in a state of solution, that is to say, in a state of fluidity. Were it not for the presence of heat, or of a certain degree of it, all fluids would be frozen. The ocean itself would be a quarry of ice; universal nature stiff and dead.

We see, therefore, that the elements bear not only a strict relation to the constitution of organized bodies, but a relation to each other. Water could not perform its office to the earth without air; nor exist, as water, without fire.

IV. Of light (whether we regard it as of the same substance with fire, or as a different substance,) it is altogether superfluous to expatiate upon the use. No man disputes it. The observations, therefore, which I shall offer, respect that little which we seem to know of its constitution.

Light travels from the sun at the rate of twelve million of miles in a minute. Urged by such a velocity, with what *force* must its particles drive against (I will not say the eye, the tenderest of animal substances, but) every substance, animate or inanimate, which stands in its way! It might seem to be a force sufficient to shatter to atoms the hardest bodies.

How then is this effect, the consequence of such prodigious velocity, guarded against? By a proportionable *minuteness* of the particles of which light is composed. It is impossible for the human mind to imagine to itself any thing so small as a particle of light. But this extreme exility, though difficult to conceive, it is easy to prove. A drop of tallow expended in the wick of a farthing candle, shall send forth rays sufficient to fill a hemisphere of a mile diameter; and to fill it so full of these rays, that an aperture not larger than the pupil of an eye, wherever it be placed within the hemisphere, shall be sure to receive some of them. What floods of light are continually poured from the sun, we cannot estimate; but the immensity of the sphere which is filled with its particles, even

if it reached no farther than the orbit of the earth, we can in some sort compute; and we have reason to believe, that throughout this whole region, the particles of light lie, in latitude at least, near to one another. The spissitude of the sun's rays at the earth is such, that the number which falls upon a burning-glass of an inch diameter, is sufficient, when concentrated, to set wood on fire.

The tenuity and the velocity of particles of light, as ascertained by separate observations, may be said to be proportioned to each other; both surpassing our utmost stretch of comprehension; but proportioned. And it is this proportion alone which converts a tremendous element into a welcome visitor.

It has been observed to me by a learned friend, as having often struck his mind, that if light had been made by a common artist, it would have been of one uniform *colour;* whereas, by its present composition, we have that variety of colours which is of such infinite use to us for the distinguishing of objects; which adds so much to the beauty of the earth, and augments the stock of our innocent pleasures.

With which may be joined another reflection, viz. that, considering light as compounded of rays of seven different colours, (of which there can be no doubt, because it can be resolved into these rays by simply passing it through a prism,) the constituent parts must be well mixed and blended toge-

ther, to produce a fluid so clear and colourless as a beam of light is, when received from the sun.

CHAPTER XXII.

ASTRONOMY.*

My opinion of Astronomy has always been, that it is *not* the best medium through which to prove the agency of an intelligent Creator; but that, this being proved, it shows, beyond all other sciences, the magnificence of his operations. The mind which is once convinced, it raises to sublimer views of the Deity than any other subject affords; but it is not so well adapted as some other subjects are to the purpose of argument. We are destitute of the means of examining the constitution of the heavenly bodies. The very simplicity of their appearance is against them. We see nothing but bright points, luminous circles, or the phases of spheres reflecting the light which falls upon them. Now we deduce design from relation, aptitude, and

* For the articles in this chapter marked with an asterisk, I am indebted to some obliging communications received (through the hands of the Lord Bishop of Elphin) from the Rev. J. Brinkley, D. D. Andrew's Professor of Astronomy in the University of Dublin.—Paley.

Fig. 1.

Fig. 2.

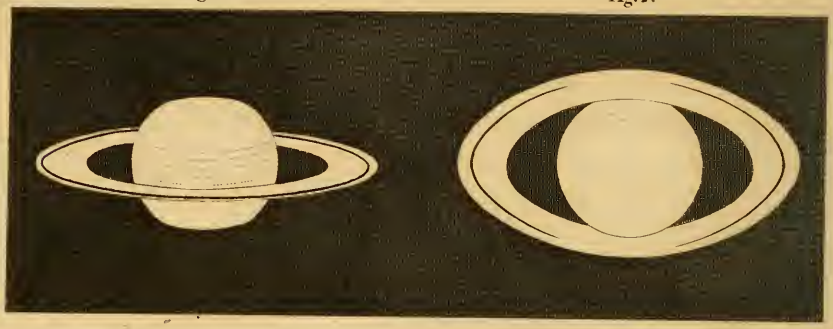
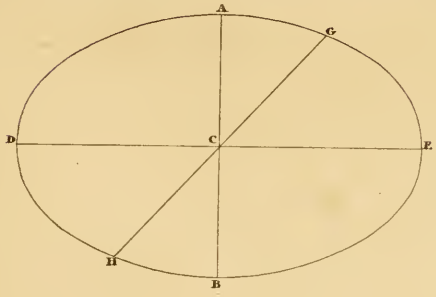


Fig. 3.



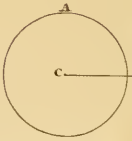


Fig. 5.

Fig. 6.

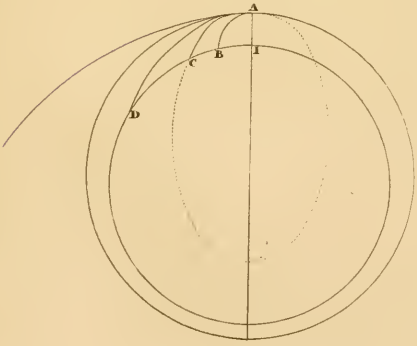
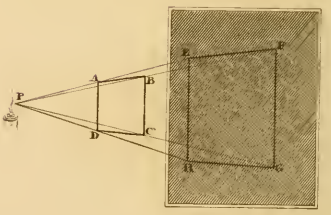


Fig. 4.



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correspondence of *parts*. Some degree therefore of *complexity* is necessary to render a subject fit for this species of argument. But the heavenly bodies do not, except perhaps in the instance of Saturn's* ring, present themselves to our observation as compounded of parts at all. This, which may be a perfection in them, is a disadvantage to us, as inquirers after their nature. They do not come within our mechanics.

And what we say of their forms, is true of their *motions*. Their motions are carried on without any sensible intermediate apparatus; whereby we are cut off from one principal ground of argumentation—analogy. We have nothing wherewith to compare them; no invention, no discovery, no operation or resource of art, which, in this respect, resembles them. Even those things which are made to imitate and represent them, such as orreries, planetaria, celestial globes, &c. bear no affinity to them, in the cause and principle by which their motions are actuated. I can assign for this difference a reason of utility, viz. a reason why, though the action of *terrestrial* bodies upon each other be,

* The remarkable appearance of the ring, which surrounds the planet Saturn is represented in Tab. XXXIX.: as this ring is inclined to the plane, in which the earth is moving, it sometimes appears as a narrow oval as in Fig. 1. and sometimes of a more open form as in Fig. 2. In this latter situation Sir William Herschell observed that it was divided into two, by a vacant space, the breadth of which was about 2513 miles. He saw the shadows of the two rings on the body of the planet.

in almost all cases, through the intervention of solid or fluid substances, yet central attraction does not operate in this manner. It was necessary that the intervals between the planetary orbs should be devoid of any *inert* matter either fluid or solid, because such an intervening substance would, by its resistance, destroy those very motions which attraction is employed to preserve. This may be a final cause of the difference; but still the difference destroys the analogy.*

Our ignorance, moreover, of the *sensitive* natures by which other planets are inhabited, necessarily keeps from us the knowledge of numberless utilities, relations, and subserviences, which we perceive upon our own globe.

After all; the real subject of admiration is, that we understand so much of astronomy as we do. That an animal confined to the surface of one of the planets; bearing a less proportion to it than the smallest microscopic insect† does to the plant

* The moon has no perceptible atmosphere: and as no effects have been observed like those, which would be produced by vapours or exhalations from its surface, it is possible that there are no fluids upon it. There is no reason, however, from these circumstances for denying the existence of sensitive beings upon it, although they must be very differently constituted from ourselves, to whom air and water are essentially necessary.

† Hooke describes a minute animalcule, which he discovered with a microscope, upon the vine. From his data an estimate may be made of its bulk; but it is not so easy to fix upon any determinate quantity for the size of the plant. However, to put the case strongly, let the bulk of it be taken as equal to that of a cylin-

it lives upon; that this little, busy, inquisitive creature, by the use of senses which were given to it for its domestic necessities, and by means of the assistance of those senses which it has had the art to procure, should have been enabled to observe the whole system of worlds to which its own belongs; the changes of place of the immense globes which compose it; and with such accuracy, as to mark out, beforehand, the situation in the heavens in which they will be found at any future point of time; and that these bodies, after sailing through regions of void and trackless space, should arrive at the place where they were expected, not within a minute, but within a few seconds of a minute, of the time prefixed and predicted: all this is wonderful, whether we refer our admiration to the constancy of the heavenly motions themselves, or to the perspicacity and precision with which they have been noticed by mankind. Nor is this the whole, nor indeed the chief part of what astronomy teaches. By bringing reason to bear upon observation (the acutest reasoning upon the exactest observation) the astronomer has been able, out of the "mystic dance," and the confusion (for such it is) under which the motions of the heavenly bodies present themselves to the eye of a mere gazer

der one inch in diameter and a mile in length. Such a cylinder would contain above 345 cubic feet, and yet it would be many million times less when compared with the animalcule than the earth is when compared with the bulk of a man.

upon the skies, to elicit their order and their real paths.

Our knowledge, therefore, of astronomy is admirable, though imperfect; and, amidst the confessed desiderata and desideranda which impede our investigation of the wisdom of the Deity, in these the grandest of his works, there are to be found, in the phenomena, ascertained circumstances and laws, sufficient to indicate an intellectual agency in three of its principal operations, viz. in choosing, in determining, in regulating: in *choosing*, out of a boundless variety of suppositions which were equally possible, that which is beneficial; in *determining*, what, left to itself, had a thousand chances against conveniency, for one in its favour; in *regulating* subjects, as to quantity and degree, which, by their nature, were unlimited with respect to either. It will be our business to offer, under each of these heads, a few instances, such as best admit of a popular explication.

I. Amongst proofs of choice, one is, fixing the source of light and heat in the *centre* of the system. The sun is ignited and luminous; the planets which move round him, cold and dark. There seems to be no antecedent necessity for this order. The sun might have been an opaque mass; some one, or two, or more, or any, or all the planets, globes of fire. There is nothing in the nature of the heavenly bodies, which requires that those which are stationary should be on fire, that

those which move should be cold; for, in fact, comets are bodies on fire,* or at least capable of the most intense heat, yet revolve round a centre; nor does this order obtain between the primary planets and their secondaries, which are all opaque. When we consider, therefore, that the sun is one; that the planets going round it are at least† seven; that it is indifferent to their nature, which are luminous and which are opaque; and also, in what order, with respect to each other, these two kinds of bodies are disposed; we may judge of the improbability of the present arrangement taking place by chance.

If, by way of accounting for the state in which we find the solar system, it be alleged (and this is one amongst the guesses of those who reject an in-

* It may be reasonably doubted whether comets are ever absolutely "on fire," and yet some of them, from their near approach to the sun, must certainly be "capable of intense heat." If we conceive the earth's distance from the sun to be divided into 1000 parts, the comet of 1680 was, at one time, not more distant than six of those parts from the sun. From hence Sir I. Newton calculated that it was exposed to a heat which was two thousand times greater than that of a red-hot iron.

† The seven planets here alluded to are Mercury, Venus, the Earth, Mars, Jupiter, Saturn, and the Georgium Sidus: we now know that there are four more, Ceres, Pallas, Juno, and Vesta; the first of these was discovered in 1801, the second was observed in March 1802, the third was not discovered till 1804, nor the last till 1807. Now Dr. Paley's dedication is dated July 1802; it is very possible, therefore, that this 22nd chapter was written before he had heard of Pallas, and even while it was yet doubtful whether Ceres was a comet or a planet. This will explain the reason for his having qualified the expression, and having said "at least seven."

telligent Creator) that the planets themselves are only cooled or cooling masses, and were once, like the sun, many thousand times hotter than red-hot iron; then it follows, that the sun also himself must be in its progress towards growing cold; which puts an end to the possibility of his having existed, as he is, from eternity. This consequence arises out of the hypothesis with still more certainty, if we make a part of it, what the philosophers who maintain it have usually taught, that the planets were originally masses of matter, struck off in a state of fusion from the body of the sun by the percussion of a comet,* or by a shock from some other cause, with which we are not acquainted: for, if these masses, partaking of the nature and substance of the sun's body, have in process of time lost their heat, that body itself, in time likewise, no matter in how much longer time, must lose its heat also, and therefore be incapable of an eternal duration in the state in which we see it, either for the time to come, or the time past.

The preference of the present to any other mode of distributing luminous and opaque bodies, I take to be evident. It requires more astronomy than I am able to lay before the reader, to show, in its particulars, what would be the effect to the system, of a dark body at the centre, and of one of the planets being luminous; but I think it manifest,

* This hypothesis is examined more particularly in the latter part of the chapter.

without either plates or calculation, first, that supposing the necessary proportion of magnitude between the central and the revolving bodies to be preserved, the ignited planet would not be sufficient to illuminate and warm the rest of the system; secondly, that its light and heat would be imparted to the other planets much more irregularly than light and heat are now received from the sun.

(*) II. Another thing, in which a choice appears to be exercised, and in which, amongst the possibilities out of which the choice was to be made, the number of those which were wrong bore an infinite proportion to the number of those which were right, is in what geometricians call the *axis of rotation*. This matter I will endeavour to explain. The earth, it is well known, is not an exact globe, but an oblate spheroid, something like an orange. Now the axes of rotation, or the diameters upon which such a body may be made to turn round, are as many as can be drawn through its centre to opposite points upon its whole surface: but of these axes none are *permanent*, except either its shortest diameter, *i. e.* that which passes through the heart of the orange from the place where the stalk is inserted into it, and which is but one; or its longest diameters, at right angles with the former, which must all terminate in the single circumference which goes round the thickest part of the orange. The shortest diameter

is that upon which in fact the earth turns; and it is, as the reader sees, what it ought to be, a permament axis; whereas, had blind chance, had a casual impulse, had a stroke or push at random, set the earth a-spining, the odds were infinite, but that they had sent it round upon a wrong axis. And what would have been the consequence? The difference between a permanent axis and another axis is this: when a spheroid in a state of rotatory motion gets upon a permanent axis, it keeps there; it remains steady and faithful to its position; its poles preserve their direction with respect to the plane and to the centre of its orbit: but whilst it turns upon an axis which is *not* permanent, (and the number of those we have seen infinitely exceeds the number of the other,) it is always liable to shift and vacillate from one axis to another, with a corresponding change in the inclination of its poles. Therefore, if a planet once set off revolving upon any other than its shortest, or one of its longest axes,* the poles on its surface

* The earth being an oblate spheroid, we may suppose it to be cut by a plane passing through A B, Fig. 3, which may represent its axis, and the common section of this plane with the spheroid will be an ellipse like A D B E; of this ellipse A B will be an axis; and, from the property of the curve, it will also be the shortest line which can be drawn through the centre C. If now the diameter D E be drawn at right angles to A B, it will be the longest line which can be drawn in the ellipse, and it will represent a diameter of the equator. As the plane passing through A B is not confined to one situation more than another, D E may represent any "one of the longest axes of the spheroid," and will, as well as A B, always be a "permanent axis of rotation." But if any other diame-

would keep perpetually changing, and it never would attain a permanent axis of rotation. The effect of this unfixedness and instability would be, that the equatorial parts of the earth might become the polar, or the polar the equatorial; to the utter destruction of plants and animals, which are not capable of interchanging their situations, but are respectively adapted to their own. As to ourselves, instead of rejoicing in our temperate zone, and annually preparing for the moderate vicissitude, or rather the agreeable succession of seasons which we experience and expect, we might come to be locked up in the ice and darkness of the arctic circle, with bodies neither inured to its rigours, nor provided with shelter or defence against them. Nor would it be much better, if the trepidation of our pole, taking an opposite course, should place us under the heats of a vertical sun. But if it would fare so ill with the human inhabitant, who can live under greater varieties of latitude than any other animal; still more noxious would this translation of climate have proved to life in the rest of the creation; and most perhaps of all, in plants. The habitable earth, and its beautiful variety, might have been destroyed by a simple mischance in the axis of rotation.

III. All this, however, proceeds upon a suppo-

ter, as G H, is taken, the earth could not continue to revolve permanently about it.

sition of the earth having been formed at first an oblate spheroid. There is another supposition; and perhaps our limited information will not enable us to decide between them. The second supposition is, that the earth, being a mixed mass somewhat fluid, took, as it might do, its present form, by the joint action of the mutual gravitation of its parts and its rotatory motion. This, as we have said, is a point in the history of the earth which our observations are not sufficient to determine. For a very small depth below the surface (but extremely small, less, perhaps, than an eight-thousandth* part, compared with the depth of the centre) we find vestiges of ancient fluidity. But this fluidity must have gone down many hundred times farther than we can penetrate, to enable the earth to take its present oblate form; and whether any traces of this kind exist to that depth, we are ignorant. Calculations were made a few years ago, of the mean density of the earth, by comparing the force of its attraction with the force of attraction of a rock of granite, the bulk of which could be ascertained: and the upshot of the calculation was, that the earth upon an average, through

* The "deep St. John," one of the deepest mines in the Hartz, was found by M. Deluc to sink 1359 feet. This was in 1778, and it may, since that time, have been carried lower, but probably not to the depth of the mine of Valenciana in New Spain, the bottom of which, according to Humboldt, is 1681 feet below the surface. Now the diameter of the earth being about 7912 miles, "the eight-thousandth part of the depth of the centre" must be 2611 feet, or nearly half a mile.

its whole sphere, has twice the density of granite, or about five times that of water.* Therefore it cannot be a hollow shell, as some have formerly supposed; nor can its internal parts be occupied by central fire, or by water. The solid parts must greatly exceed the fluid parts; and the probability is, that it is a solid mass throughout, composed of substances more ponderous the deeper we go. Nevertheless, we may conceive the present face of the earth to have originated from the revolution of a sphere, covered by a surface of a compound mixture; the fluid and solid parts separating, as the surface becomes quiescent. Here then comes in the *moderating* hand of the Creator. If the water had exceeded his present proportion, even but by a trifling quantity compared with the whole globe, all the land would have been covered; had there been much less than there is, there would not have been enough to fertilize the continent.† Had the exsiccation been progressive, such as we may suppose to have been produced by an evaporating heat, how came it to stop at the point at which we see it? Why did it not stop sooner? why at

* These calculations will be found in the Philosophical Transactions for 1778, 1798, 1811, and 1821.

† Nearly three quarters of the earth's surface are covered by the sea. Now evaporation is proportionate to the surface of the fluid, and consequently a less expanse of waters would not have afforded a sufficient supply of rain, which does not now fall upon the whole, in greater quantities than are required "to fertilize the earth."

all? The mandate of the Deity will account for this; nothing else will.

IV. Of centripetal forces. By virtue of the simplest law that can be imagined, viz. that a body *continues* in the state in which it is, whether of motion or rest; and if in motion, goes on in the line in which it was proceeding, and with the same velocity, *unless* there be some cause for change: by virtue, I say, of this law, it comes to pass (what may appear to be a strange consequence) that cases arise, in which attraction, incessantly drawing a body towards a centre, never brings, nor ever will bring, the body to that centre, but keep it in eternal circulation round it. If it were possible to fire off a cannon-ball with a velocity of five miles in a second, and the resistance of the air could be taken away, the cannon-ball would for ever wheel round the earth, instead of falling down upon it.* This is the principle which sustains the heavenly motions. The Deity, having appointed this law to matter, (than which, as we have said before, no law could be more simple,) has turned it to a wonderful account in constructing planetary systems.

* If a body be projected horizontally from a station A, Fig. 6, which is at a certain height, its weight or the force of gravity will draw it towards the earth. It may be supposed to come down, for example, at B. But from the tendency which the body has to continue in the state of motion which is communicated to it, it will be carried further before it falls, if it is projected with a greater force. Hence, if this force be increased it may be made to reach C; by a greater increase it may be carried to D; or even round to A, from whence it originally set out.

The actuating cause in these systems, is an attraction, which varies reciprocally as the square of the distance; that is, of double the distance, has a quarter of the force; at half the distance four times the strength; and so on. Now, concerning this law of variation, we have three things to observe: first; that attraction for any thing we know about it, was just as capable of one law of variation as of another: secondly; that out of an infinite number of possible laws, those which were admissible for the purpose of supporting the heavenly motions, lay within certain narrow limits: thirdly; that of the admissible laws, or those which come within the limits prescribed, the law that actually prevails is the most beneficial. So far as these propositions can be made out, we may be said, I think, to prove *choice* and *regulation*: choice out of boundless variety; and regulation, of that which, by its own nature, was, in respect of the property regulated, indifferent and indefinite.

I. First then, attraction, for any thing we know about it, was originally indifferent to all laws of variation depending upon change of distance, *i. e.* just as susceptible of one law as of another. It might have been the same at all distances; it might have increased as the distance increased: or it might have diminished with the increase of the distance, yet in ten thousand different proportions from the present; it might have followed no

stated law at all. If attraction be what Cotes, with many other Newtonians, thought it to be, a primordial property of matter, not dependent upon, or traceable to, any other material cause; then, by the very nature and definition of a primordial property, it stood indifferent to all laws. If it be the agency of something immaterial, then also, for any thing we know of it, it was indifferent to all laws. If the revolution of bodies round a centre depend upon vortices,* neither are these limited to one law more than another.

There is, I know, an account given of attraction, which should seem, in its very cause, to assign to it the law which we find it to observe; and which, therefore, makes that law, a law, not of choice, but of necessity: and it is the account, which ascribes attraction to an *emanation* from the attracting body. It is probable, that the influence of such an emanation will be proportioned to the spissitude of the rays of which it is composed; which spissitude, supposing the rays to issue in right lines on all sides from a point, will be reciprocally as the square of the distance.† The ma-

* Descartes supposed that there was a fluid, which, moving round in a continued stream, carried the planets with it in their orbits. These circular streams were called vortices.

† Let the light of a candle fall upon a square object like A B C D, Fig. 4, and if a screen be placed parallel to the object and at double the distance, the shadow E F G H, received upon it, will be four times the size of the object itself. For the rays passing in straight lines by the angles A, B, C, D, the sides E F,

thematics of this solution we do not call in question: the question with us is, whether there be any sufficient reason for believing that attraction is produced by an emanation. For my part, I am totally at a loss to comprehend how particles streaming *from* a centre should draw a body *towards* it. The impulse, if impulse it be, is all the other way. Nor shall we find less difficulty in conceiving a conflux of particles, incessantly flowing to a centre, and carrying down all bodies along with it, that centre also itself being in a state of rapid motion through absolute space: for by what source is the stream fed, or what becomes of the accumulation? Add to which, that it seems to imply a contrariety of properties, to suppose an ethereal fluid to *act*, but not to *resist;* powerful enough to carry down bodies with great force towards a centre, yet, inconsistently with the nature of inert matter, powerless and perfectly yielding with respect to the motions which

F G, G H, H E, must be each double of A B, B C, C D, D A: therefore the shadow may be divided into four squares each equal in size to the object. At three times the distance from the candle, the sides of the shadow would each be three times as large as the sides of the object, and its area would, therefore, contain nine times the space. For the same reason if the distance be increased four, five, or six times, the area of the shadow will contain sixteen, twenty-five, or thirty-six squares, each equal to the object. Now the quantity of light which falls upon the object would, if it had not been intercepted, have spread over that part of the screen, which is occupied by the shadow; and as the surface is increased, over which a certain quantity of rays is spread, in the same ratio their spissitude or density will be diminished; consequently this spissitude will be reciprocally as the squares of the distances.

result from the projectile impulse. By calculations drawn from ancient notices of eclipses of the moon, we can prove that, if such a fluid exist at all, its resistance has had no sensible effect upon the moon's motion for two thousand five hundred years. The truth is, that, except this one circumstance of the variation of the attracting force at different distances agreeing with the variation of the spissitude, there is no reason whatever to support the hypothesis of an emanation; and, as it seems to me, almost insuperable reasons against it.

(*) II. Our second proposition is, that whilst the possible laws of variation were infinite, the *admissible* laws, or the laws compatible with the preservation of the system, lie within narrow limits. If the attracting force had varied according to any *direct* law of the distance, let it have been what it would, great destruction and confusion would have taken place. The direct simple proportion of the distance would, it is true, have produced an ellipse; but the perturbing forces would have acted with so much advantage, as to be continually changing the dimensions of the ellipse, in a manner inconsistent with our terrestrial creation. For instance; if the planet Saturn, so large and so remote, had attracted the earth, both in proportion to the quantity of matter contained in it, which it does; and also in any proportion to its distance; *i. e.* if it had pulled the harder for being the farther off, (instead of the reverse of it,) it would have dragged out of its

course the globe which we inhabit, and have perplexed its motions, to a degree incompatible with our security, our enjoyments, and probably our existence. Of the *inverse* laws, if the centripetal force had changed as the cube of the distance, or in any higher proprotion, that is (for I speak to the unlearned,) if, at double the distance, the attractive force had been diminished to an eighth part, or to less than that, the consequence would have been, that the planets, if they once began to approach the sun, would have fallen into his body; if they once, though by ever so little, increased their distance from the centre, would for ever have receded from it. The laws, therefore, of attraction, by which a system of revolving bodies could be upholden in their motions, lie within narrow limits, compared with the possible laws. I much under-rate the restriction, when I say that, in a scale of a mile, they are confined to an inch. All direct ratios of the distance are excluded, on account of danger from perturbing forces; all reciprocal ratios, except what lie beneath the cube of the distance, by the demonstrable consequence, that every the least change of distance would, under the operation of such laws, have been fatal to the repose and order of the system. We do not know, that is, we seldom reflect, how interested we are in this matter. Small irregularities may be endured; but changes within these limits being allowed for, the permanency of our ellipse is a

question of life and death to our whole sensitive world.

(*) III. That the subsisting law of attraction falls within the limits which utility requires, when these limits bear so small a proportion to the range of possibilities upon which chance might equally have cast it, is not, with any appearance of reason, to be accounted for by any other cause than a regulation proceeding from a designing mind. But our next proposition carries the matter somewhat farther. We say, in the third place, that, out of the different laws which lie within the limits of admissible laws, the *best* is made choice of; that there are advantages in this particular law which cannot be demonstrated to belong to any other law; and, concerning some of which, it can be demonstrated that they do not belong to any other.

(*) 1. Whilst this law prevails between each particle of matter, the *united* attraction of a sphere, composed of that matter, observes the same law. This property of the law is necessary, to render it applicable to a system composed of spheres, but it is a property which belongs to no other law of attraction that is admissible. The law of variation of the united attraction is in no other case the same as the law of attraction of each particle, one case excepted, and that is of the attraction varying directly as the distance;* the inconveniency of

* Fig. 5. Let A represent a sphere composed of particles, which mutually attract each other with a force, which varies reciprocally

which law, in other respects, we have already noticed.

We may follow this regulation somewhat farther, and still more strikingly perceive that it proceeded from a designing mind. A law both admissible and convenient was requisite. In what way is the law of the attracting globes obtained? Astronomical observations and terrestrial experiments show, that the attraction of the globes of the system is made up of the attraction of their parts; the attraction of each globe being compounded of the attractions of its parts. Now, the admissible and convenient law which exists, could not be obtained in a system of bodies gravitating by the united gravitation of their parts, unless each particle of matter were attracted by a force varying by one particular law, viz. varying inversely as the square of the distance; for, if the action of the particles be according to any other law whatever, the admissible and convenient law which is adopted could not be obtained. Here then are clearly shown regulation and design. A law both admissible and convenient was to be obtained: the mode chosen for obtaining that law was by making *each* particle of matter act. After this choice was made, then

as the squares of the distances; their united attraction, on a similar particle P without the sphere, will be according to the same law; that is, the particle will be attracted towards the sphere with a force, which will also vary reciprocally as the square of C P, its distance from the centre of the sphere.

farther attention was to be given to each particle of matter, and one, and one only particular law of action to be assigned to it. No other law would have answered the purpose intended.

(*) 2. All systems must be liable to *perturbations*. And therefore, to guard against these perturbations, or rather to guard against their running to destructive lengths, is perhaps the strongest evidence of care and foresight that can be given. Now we are able to demonstrate of our law of attraction, what can be demonstrated of no other, and what qualifies the dangers which arise from cross but unavoidable influences, that the action of the parts of our system upon one another will not cause permanently increasing irregularities, but merely periodical or vibratory ones; that is, they will come to a limit, and then go back again. This we can demonstrate only of a system, in which the following properties concur, viz. that the force shall be inversely as the square of the distance; the masses of the revolving bodies small, compared with that of the body at the centre; the orbits not much inclined to one another; and their eccentricity little. In such a system the grand points are secure. The mean distances and periodic times, upon which depend our temperature and the regularity of our year, are constant. The eccentricities, it is true, will still vary, but so slowly, and to so small an extent, as to produce no inconveniency from fluctuation of temperature and season. The

same as to the obliquity of the planes of the orbits. For instance, the inclination of the ecliptic to the equator will never change above two degrees (out of ninety), and that will require many thousand years in performing.

It has been rightly also remarked, that if the great planets, Jupiter and Saturn, had moved in lower spheres, their influences would have had much more effect, as to disturbing the planetary motions, than they now have. While they revolve at so great distances from the rest, they act almost equally on the sun and on the interior planets; which has nearly the same consequence as not acting at all upon either.

If it be said that the planets might have been sent round the sun in exact circles, in which case, no change of distance from the centre taking place, the law of variation of the attracting power would have never come in question, one law would have served as well as another; an answer to the scheme may be drawn from the consideration of these same perturbing forces. The system retaining in other respects its present constitution, though the planets had been at first sent round in exact circular orbits, they could not have kept them: and if the law of attraction had not been what it is, or at least, if the prevailing law had transgressed the limits above assigned, every evagation would have been fatal: the planet once drawn, as drawn it necessarily must have been,

out of its course, would have wandered in endless error.

(*) V. What we have seen in the law of the centripetal force, viz. a choice guided by views of utility, and a choice of one law out of thousands which might equally have taken place, we see no less in the *figures* of the planetary orbits. It was not enough to fix the law of the centripetal force, though by the wisest choice; for even under that law, it was still competent to the planets to have moved in paths possessing so great a degree of eccentricity, as, in the course of every revolution, to be brought very near to the sun, and carried away to immense distances from him. The comets actually move in orbits of this sort; and had the planets done so, instead of going round in orbits nearly circular, the change from one extremity of temperature to another must, in ours at least, have destroyed every animal and plant upon its surface. Now, the distance from the centre at which a planet sets off, and the absolute force of attraction at that distance, being fixed, the figure of his orbit its being a circle, or nearer to, or farther off from a circle, viz. a rounder or a longer oval, depends upon two things, the velocity with which, and the direction in which, the planet is projected. And these, in order to produce a right result, must be both brought within certain narrow limits. One, and only one, velocity united with one, and only one, direction, will produce a perfect circle. And

the velocity must be near to this velocity, and the direction also near to this direction, to produce orbits, such as the planetary orbits are, nearly circular; that is, ellipses with small eccentricities. The velocity and the direction must *both* be right. If the velocity be wrong, no direction will cure the error; if the direction be in any considerable degree oblique, no velocity will produce the orbit required. Take for example the attraction of gravity at the surface of the earth. The force of that attraction being what it is, out of all the degrees of velocity, swift and slow, with which a ball might be shot off, none would answer the purpose of which we are speaking, but what was nearly that of five miles in a second.* If it were less

* The moon describes in one second of time nearly two-thirds of a mile in its orbit round the earth: and if its distance were diminished it might still continue to revolve nearly in a circle round the same centre, if its velocity were increased so as to compensate for the greater attraction, which would now draw it constantly out of the rectilinear direction, in which it would otherwise move. This distance may be supposed to be diminished till the moon is brought near to the earth's surface, and it would, under these circumstances, still continue to complete its revolution, if its velocity were increased to about five miles in a second. Now for the description of such a revolution, there is no difference between the moon and any other material substance at the same distance; for they would both be drawn down through the same space in the same time by the force of attraction towards the earth's centre; and therefore a cannon ball projected parallel to the horizon with this velocity would (if there were no resistance from the air or other accidental circumstance) complete its circular revolution, and come back to the place from which it had set out, in a few minutes less than an hour and a half, which is equivalent to the velocity of about five miles in a second.

than that, the body would not get round at all, but would come to the ground; if it were in any considerable degree more than that, the body would take one of those eccentric courses, those long ellipses of which we have noticed the inconveniency. If the velocity reached the rate of seven miles in a second, or went beyond that, the ball would fly off from the earth, and never be heard of more. In like manner with respect to the *direction;* out of the innumerable angles in which the ball might be sent off, (I mean angles formed with a line drawn to the centre,) none would serve but what was nearly a right one;* out of the

* The ball is supposed to be fired from a place not far from the earth's surface, it can therefore be easily conceived that if its direction is much depressed below the horizon, it must be soon brought down to the ground; but it is not equally obvious that an elevation of any magnitude would likewise prevent its completing its revolution round the earth. Abstracting from the air's resistance, and of course omitting the supposition of a projectile force sufficient to carry the ball off into infinite space, it will move in the curve of an ellipse, of which one of the foci is situated in the centre of the earth. Now a body moving uninterruptedly in an ellipse must return in time to the same point from which it set out. The body therefore which, when projected from A, Fig. 6. comes down to the earth at C, would have continued its course along the dotted line and returned to A, if the mass of matter in the earth had been collected together at its centre, so as not to interfere with the motion of the projectile. Let us now conceive the body to be projected back from C, with the velocity which it had acquired in its fall, and with the direction in which it reached the earth, it would then pass through A, and come down on the other side of A I, in just the same curve, in which it had fallen from A to C. The same would apply to bodies projected upwards from B or D; and if the velocities of projection were less or greater than what would have been acquired in falling from A, the bodies would still turn, but at some less or more distant point. The longest diameter,

various directions in which the cannon might be pointed, upwards and downwards, every one would fail, but what was exactly or nearly horizontal. The same thing holds true of the planets: of our own amongst the rest. We are entitled therefore to ask, and to urge the question, why did the projectile velocity and projectile direction of the earth happen to be nearly those which would retain it in a *circular* form? Why not one of the infinite number of velocities, one of the infinite number of directions, which would have made it approach much nearer to, or recede much farther from, the sun?

The planets going round, all in the same direction, and all nearly in the same plane, afforded to Buffon a ground for asserting, that they had all been shivered from the sun by the same stroke of a comet, and by that stroke projected into their present orbits. Now, besides that this is to attribute to chance the fortunate concurrence of velocity and direction which we have been here noticing, the hypothesis, as I apprehend, is incon-

however, of the ellipsis in which they move must always pass through the earth's centre, and if the bodies rise on one side of this diameter they must fall down on the other. Now it will be seen that the curves at B, C, and D, make the angles ABI, ACI, ADI less, as the body is supposed to go farther and farther before it falls, and that the curves, in which the body can complete a revolution near the surface, will in all its parts be nearly parallel to it. Hence the cannon ball fired upwards will come back again to the ground and not be able completely to go round the earth upon any other supposition excepting that of its being fired in nearly an horizontal direction.

sistent with the physical laws by which the heavenly motions are governed. If the planets were struck off from the surface of the sun, they would return to the sun again. Nor will this difficulty be got rid of, by supposing that the same violent blow which shattered the sun's surface, and separated large fragments from it, pushed the sun himself out of his place; for the consequence of this would be, that the sun and system of shattered fragments would have a progressive motion, which indeed may possibly be the case with our system; but then each fragment would, in every revolution, return to the surface of the sun again. The hypothesis is also contradicted by the vast difference which subsists between the *diameters* of the planetary orbits. The distance of Saturn from the sun (to say nothing of the Georgium Sidus) is nearly five- and twenty times that of Mercury; a disparity, which it seems impossible to reconcile with Buffon's scheme.* Bodies starting from the same place, with whatever difference of direction or velocity they set off, could not have been found, at these different distances from the centre, still retaining their nearly circular orbits. They must have been

* Buffon published his "Theorie de la Terre" in 1744, and afterwards incorporated it in the first volume of his "Histoire Naturelle," which he published in 1749. M. La Place in the last chapter of his "System du Monde," discusses and refutes this hypothesis of the planets having been struck off from the sun by the collision of a comet.

carried to their proper distances before they were projected.*

To conclude: in astronomy, the great thing is to raise the imagination to the subject, and that oftentimes in opposition to the impression made upon the senses. An illusion, for example, must be gotten over, arising from the distance at which we view the heavenly bodies, viz. the apparent *slowness* of their motions. The moon shall take some hours in getting half a yard from a star which it touched. A motion so deliberate, we may think easily guided. But what is the fact? The moon, in fact, is, all this while, driving through the heavens, at the rate of considerably more than two thousand miles in an hour; which is more than double of that with which a ball is shot off from the mouth of a cannon. Yet is this prodigious rapidity as much under government, as if the planet proceeded ever so slowly, or were conducted in its

* "If we suppose the matter of the system to be accumulated in the centre by its gravity, *no* mechanical principles, with the assistance of this power of gravity, could separate the vast mass into such parts as the sun and planets; and after carrying them to their different distances, project them in their several directions, preserving still the quality of action and reaction, or the state of the centre of gravity of the system. Such an exquisite structure of things could only arise from the contrivance and powerful influences of an intelligent, free, and most potent agent. The same powers, therefore, which at present govern the material universe, and conduct its various motions, are *very different* from those which were necessary to have produced it from nothing, or to have disposed it in the admirable form in which it now proceeds."—Maclaurin's Account of Newton's Philosophy, p. 407. edit. 3.—PALEY.

course inch by inch. It is also difficult to bring the imagination to conceive (what yet, to judge tolerably of the matter, it is necessary to conceive) how *loose*, if we may so express it, the heavenly bodies are. Enormous globes, held by nothing, confined by nothing,* are turned into free and boundless space, each to seek its course by the virtue of an invisible principle; but a principle, one, common, and the same in all; and ascertainable. To preserve such bodies from being lost, from running together in heaps, from hindering and distracting one another's motions, in a degree inconsistent with any continuing order; *i. e.* to cause them to form planetary systems, systems that, when formed, can be upheld, and more especially, systems accommodated to the organized and sensitive natures which the planets sustain, as we know to be the case, where alone we can know what the case is, upon our earth: all this requires an intelligent interposition, because it can be demonstrated concerning it, that it requires an adjustment of force, distance, direction, and velocity, out of the reach of chance to have produced; an adjustment, in its view to utility, similar to that which we see in ten thousand subjects of nature which are nearer to us, but in power, and in extent of space through which that power is exerted, stupendous.

* "Held by nothing, confined by nothing," which is material or mechanical.

But many of the heavenly bodies, as the sun and fixed stars, are *stationary*. Their rest must be the effect of an absence or of an equilibrium of attractions. It proves also, that a projectile impulse was originally given to some of the heavenly bodies, and not to others. But farther; if attraction act at all distances, there can be only one quiescent centre of gravity in the universe: and all bodies whatever must be approaching this centre, or revolving round it. According to the first of these suppositions, if the duration of the world had been long enough to allow of it, all its parts, all the great bodies of which it is composed, must have been gathered together in a heap round this point. No changes, however, which have been observed, afford us the smallest reason for believing that either the one supposition or the other is true: and then it will follow, that attraction itself is controlled or suspended by a superior agent; that there is a power above the highest of the powers of material nature; a will which restrains and circumscribes the operations of the most extensive.*

* It must here however be stated, that many astronomers deny that any of the heavenly bodies are absolutely stationary. Some of the brightest of the fixed stars have certainly small motions; and of the rest the distance is too great, and the intervals of our observation too short, to enable us to pronounce with certainty that they may not have the same. The motions in the fixed stars which have been observed, are considered either as proper to each of them, or as compounded of the motion of our system, and of motions proper to each star. By a comparison of these motions, a motion in our system is supposed to be discovered. By continuing

CHAPTER XXIII.

OF THE PERSONALITY OF THE DEITY.

CONTRIVANCE, if established, appears to me to prove every thing which we wish to prove. Amongst other things, it proves the *personality* of the Deity, as distinguished from what is sometimes called nature, sometimes called a principle: which terms, in the mouths of those who use them philosophically, seem to be intended to admit and to express an efficacy, but to exclude and to deny a personal agent. Now that which can contrive, which can design, must be a person. These capa-

this analogy to other, and to all systems, it is possible to suppose that attraction is unlimited, and that the whole material universe is revolving round some fixed point within its containing sphere or space.—PALEY.

The milky way is known to derive its appearance from a congeries of very small stars, but there are luminous spots in the heaven, which cannot be separated into distinct stars by the most powerful telescopes; these have been observed in some instances to alter their form, which Sir W. Herschell attributed to the mutual attraction of the luminous particles which composed them.

Some of the fixed stars appear double and even multiple when highly magnified. The same great astronomer, whom we have just mentioned, was induced to believe that these were separate systems, and his son, assisted by Mr. South, has established that some of them have undoubtedly a revolution round a common centre of gravity analogous to the motions of the sun and planets.

cities constitute personality, for they imply consciousness and thought. They require that which can perceive an end or purpose; as well as the power of providing means, and of directing them to their end.* They require a centre in which perceptions unite, and from which volitions flow; which is mind. The acts of a mind prove the existence of a mind; and in whatever a mind resides, is a person. The seat of intellect is a person. We have no authority to limit the properties of mind to any particular circumspection of space. These properties subsist in created nature under a great variety of sensible forms. Also every animated being has its *sensorium;* that is, a certain portion of space, within which perception and volition are exerted. This sphere may be enlarged to an indefinite extent; may comprehend the universe; and, being so imagined, may serve to furnish us with as good a notion as we are capable of forming, of the *immensity* of the Divine Nature, *i. e.* of a Being, infinite, as well in essence as in power; yet nevertheless a person.

"No man hath seen God at any time." And this, I believe, makes the great difficulty. Now it is a difficulty which chiefly arises from our not duly estimating the state of our faculties. The Deity, it is true, is the object of none of our

* Priestley's Letters to a Philosophical Unbeliever, p. 153. edit. 2.

senses: but reflect what limited capacities animal senses are. Many animals seem to have but one sense, or perhaps two at the most; touch and taste. Ought such an animal to conclude against the existence of odours, sounds, and colours? To another species is given the sense of smelling. This is an advance in the knowledge of the powers and properties of nature: but, if this favoured animal should infer from its superiority over the class last described, that it perceived every thing which was perceptible in nature, it is known to us, though perhaps not suspected by the animal itself, that it proceeded upon a false and presumptuous estimate of its faculties. To another is added the sense of hearing; which lets in a class of sensations entirely unconceived by the animal before spoken of; not only distinct, but remote from any which *it* had ever experienced, and greatly superior to them. Yet this last animal has no more ground for believing, that its senses comprehend all things, and all properties of things, which exist, than might have been claimed by the tribes of animals beneath it; for we know that it is still possible to possess another sense, that of sight, which shall disclose to the percipient a new world. This fifth sense makes the animal what the human animal is: but to infer, that possibility stops here; that either this fifth sense is the last sense, or that the five comprehend all existence, is just as unwarrantable a conclusion, as that which

might have been made by any of the different species which possessed fewer, or even by that, if such there be, which possessed only one. The conclusion of the one-sense animal, and the conclusion of the five-sense animal, stand upon the same authority. There may be more and other senses than those which we have. There may be senses suited to the perception of the powers, properties, and substance of spirits. These may belong to higher orders of rational agents: for there is not the smallest reason for supposing that we are the highest, or that the scale of creation stops with us.

The great *energies* of nature are known to us only by their effects. The substances which produce them, are as much concealed from our senses as the Divine Essence itself. *Gravitation*, though constantly present, though constantly exerting its influence, though every where around us, near us, and within us; though diffused throughout all space, and penetrating the texture of all bodies with which we are acquainted, depends, if upon a fluid, upon a fluid which, though both powerful and universal in its operation, is no object of sense to us; if upon any other kind of substance or action, upon a substance and action from which *we* receive no distinguishable impressions. Is it then to be wondered at, that it should, in some measure, be the same with the Divine Nature?

Of this, however, we are certain, that whatever the Deity be, neither the *universe*, nor any part

of it which we see, can be He. The universe itself is merely a collective name: its parts are all which are real; or which are *things*. Now inert matter is out of the question; and organized substances include marks of contrivance. But whatever includes marks of contrivance, whatever, in its constitution, testifies design, necessarily carries us to something beyond itself, to some other being, to a designer prior to, and out of itself. No animal, for instance, can have contrived its own limbs and senses; can have been the author to itself of the design with which they were constructed. That supposition involves all the absurdity of self-creation, *i. e.* of acting without existing. Nothing can be God, which is ordered by a wisdom and a will which itself is void of; which is indebted for any of its properties to contrivance *ab extra*. The *not* having that in his nature which requires the exertion of another prior being (which property is sometimes called self-sufficiency, and sometimes self-comprehension,) appertains to the Deity, as his essential distinction, and removes his nature from that of all things which we see. Which consideration contains the answer to a question that has sometimes been asked, namely, Why, since something or other must have existed from eternity, may not the present universe be that something? The contrivance perceived in it proves that to be impossible. Nothing contrived can, in a strict and proper

sense, be eternal, forasmuch as the contriver must have existed before the contrivance.

Wherever we see marks of contrivance, we are led for its cause to an *intelligent* author. And this transition of the understanding is founded upon uniform experience. We see intelligence constantly contriving; that is, we see intelligence constantly producing effects, marked and distinguished by certain properties; not certain particular properties, but by a kind and class of properties, such as relation to an end, relation of parts to one another, and to a common purpose. We see, wherever we are witnesses to the actual formation of things, nothing except intelligence producing effects so marked and distinguished. Furnished with this experience, we view the productions of nature. We observe *them* also marked and distinguished in the same manner. We wish to account for their origin. Our experience suggests a cause perfectly adequate to this account. No experience, no single instance or example, can be offered in favour of any other. In this cause therefore we ought to rest; in this cause the common sense of mankind has, in fact, rested, because it agrees with that, which, in all cases, is the foundation of knowledge,—the undeviating course of their experience. The reasoning is the same as that by which we conclude any ancient appearances to have been the effects of volcanoes or inundations, namely, because they resemble the

effects which fire and water produce before our eyes; and because we have never known these effects to result from any other operation. And this resemblance may subsist in so many circumstances, as not to leave us under the smallest doubt in forming our opinion. Men are not deceived by this reasoning: for whenever it happens, as it sometimes does happen, that the truth comes to be known by direct information, it turns out to be what was expected. In like manner, and upon the same foundation (which in truth is that of experience) we conclude that the works of nature proceeded from intelligence and design, because, in the properties of relation to a purpose, subserviency to a use, they resemble what intelligence and design are constantly producing, and what nothing except intelligence and design ever produce at all. Of every argument, which would raise a question as to the safety of this reasoning, it may be observed, that if such argument be listened to, it leads to the inference, not only that the present order of nature is insufficient to prove the existence of an intelligent Creator, but that no imaginable order would be sufficient to prove it; that *no* contrivance, were it ever so mechanical, ever so precise, ever so clear, ever so perfectly like those which we ourselves employ, would support this conclusion. A doctrine to which, I conceive, no sound mind can assent.

The force, however, of the reasoning is some-

times sunk by our taking up with mere names. We have already noticed,* and we must here notice again, the misapplication of the term "law," and the mistake concerning the idea which that term expresses in physics, whenever such idea is made to take the place of power, and still more of an intelligent power, and, as such, to be assigned for the cause of any thing, or of any property of any thing, that exists. This is what we are secretly apt to do, when we speak of organized bodies (plants for instance, or animals,) owing their production, their form, their growth, their qualities, their beauty, their use, to any law or laws of nature; and when we are contented to sit down with that answer to our inquiries concerning them. I say once more, that it is a perversion of language to assign any law as the efficient operative cause of any thing. A law presupposes an agent, for it is only the mode according to which an agent proceeds; it implies a power, for it is the order according to which that power acts. Without this agent, without this power, which are both distinct from itself, the "law" does nothing; is nothing.

What has been said concerning "law" holds true of *mechanism*. Mechanism is not itself power. Mechanism, without power, can do nothing. Let a watch be contrived and constructed ever so in-

* Chap. I. sect. vii.

geniously; be its parts ever so many, ever so complicated, ever so finely wrought or artificially put together, it cannot *go* without a weight or spring, *i. e.* without a force independent of, and ulterior to, its mechanism. The spring acting at the centre, will produce different motions and different results, according to the variety of the intermediate mechanism. One and the self-same spring, acting in one and the same manner, viz. by simply expanding itself, may be the cause of a hundred different, and all useful, movements, if a hundred different and well-devised sets of wheels be placed between it and the final effect; *e. g.* may point out the hour of the day, the day of the month, the age of the moon, the position of the planets, the cycle of the years, and many other serviceable notices: and these movements may fulfil their purposes with more or less perfection, according as the mechanism is better or worse contrived, or better or worse executed, or in a better or worse state of repair; *but in all cases, it is necessary that the spring act at the centre.* The course of our reasoning upon such a subject would be this: by inspecting the watch, even when standing still, we get a proof of contrivance, and of a contriving mind having been employed about it. In the form and obvious relation of its parts, we see enough to convince us of this. If we pull the works in pieces, for the purpose of a closer examination, we are still more fully convinced. But

when we see the watch *going*, we see proof of another point, viz. that there is a power somewhere and somehow or other, applied to it; a power in action;—that there is more in the subject than the mere wheels of the machine;—that there is a secret spring, or a gravitating plummet; in a word, that there is force and energy, as well as mechanism.

So then, the watch in motion establishes to the observer two conclusions: one; that thought, contrivance, and design, have been employed in the forming, proportioning, and arranging of its parts; and that whoever or wherever he be, or were, such a contriver there is, or was: the other; that force or power, distinct from mechanism, is at this present time acting upon it. If I saw a hand-mill even at rest, I should see contrivance: but if I saw it grinding, I should be assured that a hand was at the windlass though in another room. It is the same in nature. In the works of nature we trace mechanism; and this alone proves contrivance: but living, active, moving, productive nature, proves also the exertion of a power at the centre; for, wherever the power resides may be denominated the centre.

The intervention and disposition of what are called "*second causes*," fall under the same observation. This disposition is or is not mechanism, according as we can or cannot trace it by our senses and means of examination. That is all the

difference there is; and it is a difference which respects our faculties, not the things themselves. Now, where the order of second causes is mechanical, what is here said of mechanism strictly applies to it. But it would be always mechanism (natural chemistry, for instance, would be mechanism) if our senses were acute enough to descry it. Neither mechanism, therefore, in the works of nature, nor the intervention of what are called second causes, (for I think that they are the same thing,) excuses the necessity of an agent distinct from both.

If, in tracing these causes, it be said, that we find certain general properties of matter which have nothing in them that bespeaks intelligence, I answer, that still the *managing* of these properties, the pointing and directing them to the uses which we see made of them, demands intelligence in the highest degree. For example: suppose animal secretions to be elective attraction, and that such and such attractions universally belong to such and such substances; in all which there is no intellect concerned; still the choice and collocation of these substances, the fixing upon right substances, and disposing them in right places, must be an act of intelligence, What mischief would follow, were there a single transposition of the secretory organs; a single mistake in arranging the glands which compose them!

There may be many second causes, and many courses of second causes, one behind another, between what we observe of nature and the Deity: but there must be intelligence somewhere; there must be more in nature than what we see; and, amongst the things unseen, there must be an intelligent, designing author. The philosopher beholds with astonishment the production of things around him. Unconscious particles of matter take their stations, and severally arrange themselves in an order, so as to become collectively plants or animals, *i. e.* organized bodies, with parts bearing strict and evident relation to one another, and to the utility of the whole: and it should seem that these particles could not move in any other way than as they do; for they testify not the smallest sign of choice, or liberty or discretion. There may be particular intelligent beings guiding these motions in each case; or they may be the result of trains of mechanical dispositions, fixed beforehand by an intelligent appointment, and kept in action by a power at the centre. But, in either case, there must be intelligence.

The minds of most men are fond of what they call a *principle*, and of the appearance of simplicity, in accounting for phenomena. Yet this principle, this simplicity, resides merely in the *name;* which name, after all, comprises perhaps under it, a diversified, multifarious, or progressive operation,

distinguishable into parts. The power in organized bodies, of producing bodies like themselves, is one of these principles. Give a philosopher this, and he can get on. But he does not reflect, what this mode of production, this principle (if such he choose to call it) requires; how much it presupposes; what an apparatus of instruments, some of which are strictly mechanical, is necessary to its success; what a train it includes of operations and changes, one succeeding another, one related to another, one ministering to another; all advancing, by intermediate, and frequently, by sensible steps, to their ultimate result! Yet, because the whole of this complicated action is wrapped up in a single term, *generation*, we are to set it down as an elementary principle; and to suppose, that when we have resolved the things which we see into this principle, we have sufficiently accounted for their origin, without the necessity of a designing, intelligent Creator. The truth is, generation is not a principle, but a *process*. We might as well call the casting of metals a principle; we might, so far as appears to me, as well call spinning and weaving principles: and then, referring the texture of cloths, the fabric of muslins and calicoes, the patterns of diapers and damasks, to these, as principles, pretend to dispense with intention, thought, and contrivance, on the part of the artist; or to dispense, indeed, with the necessity of any artist at all, either in the

manufacturing of the article, or in the fabrication of the machinery by which the manufacture was carried on.

And after all, how, or in what sense, is it true, that animals produce their *like?* A butterfly, with a proboscis instead of a mouth, with four wings and six legs, produces a hairy caterpillar, with jaws and teeth, and fourteen feet. A frog produces a tadpole. A black beetle, with gauze wings, and a crusty covering, produces a white smooth, soft worm; an ephemeron fly, a cod-bait maggot. These, by a progress through different stages of life, and action, and enjoyment, (and in each state provided with implements and organs appropriated to the temporary nature which they bear,) arrive at last at the form and fashion of the parent animal. But all this is process, not principle; and proves, moreover, that the property of animated bodies, of producing their like, belongs to them, not as a primordial property, not by any blind necessity in the nature of things, but as the effect of economy, wisdom, and design; because the property itself assumes diversities, and submits to deviations dictated by intelligible utilities, and serving distinct purposes of animal happiness.

The opinion, which would consider "generation" as a *principle* in nature; and which would assign this principle as a cause, or endeavour to satisfy our minds with such a cause, of the existence of organized bodies, is confuted, in my judgment,

not only by every mark of contrivance discoverable in those bodies, for which it gives us no contriver, offers no account whatever; but also by the farther consideration, that things generated possess a clear relation to things *not* generated. If it were merely one part of a generated body bearing a relation to another part of the same body, as the mouth of an animal to the throat, the throat to the stomach, the stomach to the intestines, those to the recruiting of the blood, and by means of the blood, to the nourishment of the whole frame; or if it were only one generated body bearing a relation to another generated body, as the sexes of the same species to each other, animals of prey to their prey, herbivorous and granivorous animals to the plants or seeds upon which they feed, it might be contended, that the whole of this correspondency was attributable to generation, the common origin from which these substances proceeded. But what shall we say to agreements which exist between things generated and things *not generated?* Can it be doubted, was it ever doubted, but that the *lungs* of animals bear a relation to the *air*, as a permanently elastic fluid? They act in it and by it; they cannot act without it. Now, if generation produced the animal, it did not produce the air; yet their properties correspond.* The *eye* is made for *light*, and light

* In *fishes*, the apparatus for breathing bears a relation to the medium in which they live. The gills, which are the respiratory

for the eye. The eye would be of no use without light, and light perhaps of little without eyes: yet one is produced by generation; the other not. The *ear* depends upon *undulations* of air. Here are two sets of motions: first, of the pulses of the air; secondly, of the drum, bones, and nerves of the ear: sets of motions bearing an evident reference to each other: yet the one, and the apparatus for the one, produced by the intervention of generation; the other altogether independent of it.

If it be said, that the air, the light, the elements, the world itself, is *generated;* I answer, that I do not comprehend the proposition. If the term mean any thing similar to what it means when applied to plants or animals, the proposition is certainly without proof; and, I think, draws as near to absurdity as any proposition can do, which does not include a contradiction in its terms. I am at a loss to conceive, how the formation of the world can be compared to the generation of an animal. If the term generation signify something quite different from what it signifies on ordinary occasions, it may, by the same latitude, signify any thing. In which

organs, are situated on each side of the throat, and consist of myriads of blood vessels, disposed so as to have a fringed appearance, like the barbs of a feather; which being attached on each side of the convex margins of four cartilaginous or osseous arches, are themselves connected to the jaws. As the water contains a large quantity of air, it thus, by continually passing over the gills, decarbonises and oxidates the blood, producing similar effects to the gaseous respiration in the lungs of the higher orders of animals.

case, a word or phrase taken from the language of Otaheite, would convey as much theory concerning the origin of the universe, as it does to talk of its being generated.

We know a cause (intelligence) adequate to the appearances which we wish to account for; we have this cause continually producing similar appearances; yet, rejecting this cause, the sufficiency of which we know, and the action of which is constantly before our eyes, we are invited to resort to suppositions destitute of a single fact for their support, and confirmed by no analogy with which we are acquainted. Were it necessary to inquire into the *motives* of men's opinions, I mean their motives separate from their arguments, I should almost suspect, that, because the proof of a Deity drawn from the constitution of nature is not only popular but vulgar, (which may arise from the cogency of the proof, and be indeed its highest recommendation,) and because it is a species almost of *puerility* to take up with it; for these reasons, minds, which are habitually in search of invention and originality, feel a resistless inclination to strike off into other solutions and other expositions. The truth is, that many minds are not so indisposed to any thing which can be offered to them, as they are to the *flatness* of being content with common reasons: and, what is most to be lamented, minds conscious of superiority are the most liable to this pregnancy.

The "suppositions" here alluded to, all agree in one character: they all endeavour to dispense with the necessity in nature, of a particular, personal intelligence; that is to say, with the exertion of an intending, contriving mind, in the structure and formation of the organized constitution which the world contains. They would resolve all productions into *unconscious* energies, of a like kind, in that respect, with attraction, magnetism, electricity, &c. without any thing farther.

In this, the old system of the atheism and the new agree. And I much doubt, whether the new schemes have advanced any thing upon the old, or done more than changed the terms of the nomenclature. For instance, I could never see the difference between the antiquated system of atoms, and Buffon's organic molecules. This philosopher, having made a planet by knocking off from the sun a piece of melted glass, in consequence of the stroke of a comet; and having set it in motion by the same stroke, both round its own axis and the sun, finds his next difficulty to be, how to bring plants and animals upon it. In order to solve this difficulty, we are to suppose the universe replenished with particles endowed with life, but without organization or senses of their own; and endowed also with a tendency to marshal themselves into organized forms. The concourse of these particles, by virtue of this tendency, but without intelligence, will, or direction, (for I do

not find that any of these qualities are ascribed to them,) has produced the living forms which we now see.

Very few of the conjectures which philosophers hazard upon these subjects, have more of pretension in them, than the challenging you to show the direct impossibility of the hypothesis. In the present example, there seemed to be a positive objection to the whole scheme upon the very face of it; which was that, if the case were as here represented, *new* combinations ought to be perpetually taking place; new plants and animals, or organized bodies which were neither, ought to be starting up before our eyes every day. For this, however, our philosopher has an answer. Whilst so many forms of plants and animals are already in existence, and, consequently, so many "internal moulds," as he calls them, are prepared and at hand, the organic particles run into these moulds, and are employed in supplying an accession of substance to them, as well for their growth as for their propagation. By which means, things keep their ancient course. But, says the same philosopher, should any general loss or destruction of the present constitution of organized bodies take place, the particles, for want of "moulds" into which they might enter, would run into different combinations, and replenish the waste with new species of organized substances.

Is there any history to countenance this notion?

Is it known, that any destruction has been so repaired? any desert thus repeopled?

So far as I remember, the only natural appearance mentioned by our author, by way of fact whereon to build his hypothesis, is the formation of *worms* in the intestines of animals, which is here ascribed to the coalition of superabundant organic particles, floating about in the first passages; and which have combined themselves into these simple animal forms, for want of internal moulds, or of vacancies in those moulds, into which they might be received. The thing referred to, is rather a species of facts, than a single fact; as some other cases may, with equal reason, be included under it. But to make it a fact at all, or in any sort applicable to the question we must begin with asserting an *equivocal* generation, contrary to analogy, and without necessity: contrary to an analogy, which accompanies us to the very limits of our knowledge or inquiries; for wherever, either in plants or animals, we are able to examine the subject, we find procreation from a parent form: without necessity; for I apprehend that it is seldom difficult to suggest methods, by which the eggs, or spawn, or yet invisible rudiments of these vermin, may have obtained a passage into the cavities in which they are found.* Add to

* I trust I may be excused for not citing, as another fact which is to confirm the hypothesis, the grave assertion of this writer, that the branches of trees upon which the stag feeds, break out again in his horns. Such *facts* merit no discussion.

this, that their *constancy to their species*, which I believe, is as regular in these as in the other vermes, desides the question against our philosopher, if in truth any question remained upon the subject.*

Lastly; these wonder-working instruments, these "internal moulds," what are they after all? what, when examined, but a name without signification; unintelligible, if not self-contradictory; at the best, differing in nothing from the "essential forms" of the Greek philosophy? One short sentence of Buffon's work exhibits his scheme as follows: "when this nutritious and prolific matter, which is diffused throughout all nature, passes through the *internal mould* of an animal or vegetable, and finds a proper matrix, or receptacle, it gives rise to an animal or vegetable of the same species." Does any reader annex a meaning to the expression "internal mould, in this sentence? Ought it then to be said, that though we have little notion of an internal mould, we have not much more of a designing mind? The very contrary of this assertion is the truth. When we speak of an artificer or an architect, we talk of what is comprehensible to our understanding, and

* The difficulty which the hypothesis of the spontaneous production, consists in our inability to trace the pre-existence of the germs, and to follow the operations of nature, in regions of infinite minuteness. The terms spontaneous, or equivocal generation explain nothing. With the conception of creation in all its modes, whether the object be a world or a worm, our limited faculties are altogether incommensurate.

familiar to our experience. We use no other terms, than what refer us for their meaning to our consciousness and observation; what express the constant objects of both; whereas names like that we have mentioned, refer us to nothing; excite no idea; convey a sound to the ear, but I think do no more.

Another system, which has lately been brought forward, and with much ingenuity, is that of *appetencies*. The principle and the short account of the theory, is this: pieces of soft, ductile matter, being endued with propensities or appetencies for particular actions, would, by continual endeavours, carried on through a long series of generations, work themselves gradually into suitable forms; and at length acquire, though perhaps by obscure and almost imperceptible improvements, an organization fitted to the action which their respective propensities led them to exert. A piece of animated matter, for example, that was endued with a propensity to *fly*, though ever so shapeless, though no other we will suppose than a round ball, to begin with, would, in a course of ages, if not in a million of years, perhaps in a hundred millions of years, (for our theorists have eternity to dispose of, are never sparing in time,) acquire *wings*. The same tendency to locomotion in an aquatic animal, or rather in an animated lump which might happen to be surrounded by water, would end in the production of *fins;* in a living substance,

confined to the solid earth, would put out *legs* and *feet;* or, if it took a different turn, would break the body into ringlets, and conclude by *crawling* upon the ground.

Although I have introduced the mention of this theory into this place, I am unwilling to give to it the name of an *atheistic* scheme, for two reasons: first, because, so far as I am able to understand it, the original propensities, and the numberless varieties of them (so different, in this respect, from the laws of mechanical nature, which are few and simple,) are, in the plan itself, attributed to the ordination and appointment of an intelligent and designing Creator; secondly, because, likewise, that large postulatum, which is all along assumed and presupposed, the faculty in living bodies of producing other bodies organized like themselves, seems to be referred to the same cause; at least is not attempted to be accounted for by any other. In one important respect, however, the theory before us coincides with atheistic systems, viz. in that, in the formation of plants and animals, in the structure and use of their parts, it does away final causes. Instead of the parts of a plant or animal, or the particular structure of the parts, having been intended for the action or the use to which we see them applied, according to this theory, they have themselves grown out of that action, sprung from that use. The theory therefore dispenses with that which we insist upon, the

necessity, in each particular case, of an intelligent, designing mind, for the contriving and determining of the forms which organized bodies bear. Give our philosopher these appetencies; give him a portion of living irritable matter (a nerve, or the clipping of a nerve) to work upon; give also to his incipient or progressive forms, the power, in every stage of their alteration, of propagating their like; and, if he is to be believed, he could replenish the world with all the vegetable and animal productions which we at present see in it.

The scheme under consideration is open to the same objection with other conjectures of a similar tendency, viz. a total defect of evidence. No changes, like those which the theory requires, have ever been observed. All the changes in Ovid's Metamorphoses might have been effected by these appetencies, if the theory were true: yet not an example, nor the pretence of an example, is offered of a single change being known to have taken place. Nor is the order of generation obedient to the principle upon which this theory is built. The mammæ * of the male have not vanished by inusitation; *nec curtorum, per multa sæcula, Judæorum propagini deest præputium.*

* I confess myself totally at a loss to guess at the reason, either final or efficient, for this part of the animal frame, unless there be some foundation for an opinion, of which I draw the hint from a paper of Sir Everard Home, (Philosophical Transactions, 1799, p. 2.) viz. that the mammæ of the fœtus may be formed before the sex is determined.

It is easy to say, and it has been said, that the alterative process is too slow to be perceived; that it has been carried on through tracts of immeasurable time; and that the present order of things is the result of a gradation, of which no human records can trace the steps. It is easy to say this; and yet it is still true, that the hypothesis remains destitute of evidence.

The *analogies* which have been alleged, are of the following kind: the *bunch* of a camel is said to be no other than the effect of carrying burdens; a service in which the species has been employed from the most ancient times of the world. The first race, by the daily loading of the back, would probably find a small grumous tumour to be formed in the flesh of that part.* The next progeny would bring this tumour into the world with them. The life to which they were destined would increase it. The cause which first generated the tubercle being continued, it would go on, through every succession, to augment its size, till it attained the form and the bulk under which it now appears. This may serve for one instance: another, and

* It is more easy to believe, that the original organization of the camel should have been adapted to the services to which it is destined, than that the services should have altered the organization. The hump on the back is so far from being a callosity produced by friction, that it is a soft, fatty substance, which is gradually absorbed into the system when the animal is without food, and is renewed when he obtains pasturage—an evident proof that, it is one of the several admirable provisions which he possesses for his support in the desert.

that also of the passive sort, is taken from certain species of birds. Birds of the *crane* kind, as the crane itself, the heron, bittern, stork, have, in general, their thighs bare of feathers. This privation is accounted for from the habit of wading in water, and from the effect of that element to check the growth of feathers upon these parts; in consequence of which, the health and vegetation of the feathers declined through each generation of the animal; the tender down, exposed to cold and wetness, became weak, and thin, and rare, till the deterioration ended in the result which we see, of absolute nakedness. I will mention a third instance, because it is drawn from an active habit, as the two last were from passive habits: and that is the *pouch* of the pelican. The description which naturalists give of this organ, is as follows: "From the lower edges of the under chap hangs a bag, reaching from the whole length of the bill to the neck, which is said to be capable of containing fifteen quarts of water. This bag the bird has a power of wrinkling up into the hollow of the under chap. When the bag is empty, it is not seen; but when the bird has fished with success, it is incredible to what an extent it is often dilated. The first thing the pelican does in fishing, is to fill the bag; and then it returns to digest its burden at leisure. The bird preys upon the large fishes, and hides them by dozens in its pouch. When the bill is opened to its widest extent, a person

may run his head into the bird's mouth, and conceal it in this monstrous pouch, thus adapted for very singular purposes." Now this extraordinary conformation is nothing more, say our philosophers, than the result of habit; not of the habit or effort of a single pelican, or of a single race of pelicans, but of a habit perpetuated through a long series of generations. The pelican soon found the conveniency of reserving in its mouth, when its appetite was glutted, the remainder of its prey, which is fish. The fulness produced by this attempt, of course stretched the skin which lies between the under chaps, as being the most yielding part of the mouth. Every distension increased the cavity. The original bird, and many generations which succeeded him, might find difficulty enough in making the pouch answer this purpose: but future pelicans, entering upon life with a pouch derived from their progenitors, of considerable capacity, would more readily accelerate its advance to perfection, by frequently pressing down the sack with the weight of fish which it might now be made to contain.

These, or of this kind, are the analogies relied upon. Now, in the first place, the instances themselves are unauthenticated by testimony; and, in theory, to say the least of them, open to great objections. Who ever read of camels without bunches, or with bunches less than those with which they are at present usually formed? A

bunch, not unlike the camel's, is found between the shoulders of the buffalo; of the origin of which it is impossible to give the account here given. In the second example; why should the application of water, which appears to promote and thicken the growth of feathers upon the bodies and breasts of geese and swans, and other water-fowls, have divested of this covering the thighs of cranes? The third instance, which appears to me as plausible as any that can be produced, has this against it, that it is a singularity restricted to the species; whereas, if it had its commencement in the cause and manner which have been assigned, the like conformation might be expected to take place in other birds which feed upon fish. How comes it to pass, that the pelican alone was the inventress, and her descendants the only inheritors, of this curious resource?

But it is the less necessary to controvert the instances themselves, as it is a straining of analogy beyond all limits of reason and credibility, to assert that birds, and beasts, and fish, with all their variety and complexity of organization, have been brought into their forms, and distinguished into their several kinds and natures, by the same process (even if that process could be demonstrated, or had it ever been actually noticed), as might seem to serve for the gradual generation of a camel's bunch, or a pelican's pouch.

The solution, when applied to the works of na-

ture *generally*, is contradicted by many of the phenomena, and totally inadequate to others. The *ligaments* or strictures, by which the tendons are tied down at the angles of the joints, could by no possibility be formed by the motion or exercise of the tendons themselves; by any appetency exciting these parts into action; or by any tendency arising therefrom. The tendency is all the other way; the *conatus* in constant opposition to them. Length of time does not help the case at all, but the reverse. The *valves* also in the blood-vessels could never be formed in the manner which our theorist proposes. The blood, in its right and natural course, has no tendency to form them. When obstructed or refluent, it has the contrary. These parts could not grow out of their use, though they had eternity to grow in.*

The *senses* of animals appear to me altogether incapable of receiving the explanation of their origin which this theory affords. Including under the word "sense" the organ and the perception, we have no account of either. How will our philosopher get at *vision*, or make an eye? How should the blind animal affect sight, of which blind

* The inner membrane of the vein is folded in a semilunar form across the calibre of the vessel, the lower margin being placed towards the heart. The valves of veins therefore, in dependent situations, support the column of blood, and prevent its return to the surface of the body; for the valves are pressed close to the sides of the vessels during its flow towards the heart, but they are raised when the blood, from any accidental circumstance, is disposed to flow in a retrograde direction.

animals, we know, have neither conception nor desire? Affecting it, by what operation of its will, by what endeavour to see, could it so determine the fluids of its body, as to inchoate the formation of an eye; or suppose the eye formed, would the perception follow? The same of the other senses. And this objection holds its force, ascribe what you will to the hand of time, to the power of habit, to changes too slow to be observed by man, or brought within any comparison which he is able to make of past things with the present: concede what you please to these arbitrary and unattested suppositions, how will they help you? Here is no inception. No laws, no course, no powers of nature which prevail at present, nor any analogous to these, would give commencement to a new sense. And it is in vain to inquire how that might proceed, which could never *begin*.

I think the senses to be the most inconsistent with the hypothesis before us, of any part of the animal frame. But other parts are sufficiently so. The solution does not apply to the parts of animals which have little in them of motion. If we could suppose joints and muscles to be gradually formed by action and exercise, what action or exercise could form a skull, or fill it with brains? No effort of the animal could determine the clothing of its skin. What *conatus* could give prickles to the porcupine or hedgehog, or to the sheep its fleece?

In the last place: what do these appetencies mean when applied to plants? I am not able to give a signification to the term, which can be transferred from animals to plants; or which is common to both. Yet a no less successful organization is found in plants, than what obtains in animals. A solution is wanted for one as well as the other.

Upon the whole; after all the schemes and struggles of a reluctant philosophy, the necessary resort is to a Deity. The marks of *design* are too strong to be gotten over. Design must have had a designer. That designer must have been a person. That person is GOD.

CHAPTER XXIV.

OF THE NATURAL ATTRIBUTES OF THE DEITY.

IT is an immense conclusion, that there is a God; a perceiving, intelligent, designing Being; at the head of creation, and from whose will it proceeded. The *attributes* of such a Being, suppose his reality to be proved, must be adequate to the magnitude, extent, and multiplicity of his operations: which are not only vast beyond comparison with those performed by any other power,

but, so far as respects our conceptions of them, infinite, because they are unlimited on all sides.

Yet the contemplation of a nature so exalted, however surely we arrive at the proof of its existence, overwhelms our faculties. The mind feels its powers sink under the subject. One consequence of which is, that from painful abstraction the thoughts seek relief in sensible images. Whence may be deduced the ancient, and almost universal propensity to idolatrous substitutions. They are the resources of a labouring imagination. False religions usually fall in with the natural propensity; true religions, or such as have derived themselves from the true, resist it.

It is one of the advantages of the revelations which we acknowledge, that whilst they reject idolatry with its many pernicious accompaniments, they introduce the Deity to human apprehension, under an idea more personal, more determinate, more within its compass, than the theology of nature can do. And this they do by representing him exclusively under the relation in which he stands to ourselves; and, for the most part, under some precise character, resulting from that relation, or from the history of his providences. Which method suits the span of our intellects much better than the universality which enters into the idea of God, as deduced from the views of nature. When, therefore, these representations are well founded in point of authority, (for all depends upon that,)

they afford a condescension to the state of our faculties, of which, they who have most reflected on the subject, will be the first to acknowledge the want and the value.

Nevertheless, if we be careful to imitate the documents of our religion, by confining our explanations to what concerns ourselves, and do not affect more precision in our ideas than the subject allows of, the several terms which are employed to denote the attributes of the Deity, may be made, even in natural religion, to bear a sense consistent with truth and reason, and not surpassing our comprehension.

These terms are; Omnipotence, omniscience, omnipresence, eternity, self-existence, necessary existence, spirituality.

"Omnipotence," "omniscience," "infinite" power, "infinite" knowledge, are *superlatives;* expressing our conception of the attributes in the strongest and most elevated terms which language supplies. We ascribe power to the Deity under the name of "omnipotence," the strict and correct conclusion being, that a power which could create such a world as this is, must be, beyond all comparison, greater than any which we experience in ourselves, than any which we observe in other visible agents; greater also than any which we can want, for our individual protection and preservation, in the Being upon whom we depend. It is a power, likewise, to which we are not

authorized, by our observation or knowledge, to assign any limits of space or duration.

Very much of the same sort of remark is applicable to the term, "omniscience," infinite knowledge or infinite wisdom. In strictness of language, there is a difference between knowledge and wisdom; wisdom always supposing action, and action directed by it. With respect to the first, viz. *knowledge*, the Creator must know, intimately, the constitution and properties of the things which he created; which seems also to imply a foreknowledge of their action upon one another, and of their changes; at least, so far as the same result from trains of physical and necessary causes. His omniscience also, as far as respects things present, is deducible from his nature, as an intelligent being, joined with the extent, or rather the universality, of his operations. Where he acts, he is; and where he is, he perceives. The *wisdom* of the Deity, as testified in the works of creation, surpasses all idea we have of wisdom, drawn from the highest intellectual operations of the highest class of intelligent beings with whom we are acquainted; and, which is of the chief importance to us, whatever be its compass or extent, which it is evidently impossible that we should be able to determine, it must be adequate to the conduct of that order of things under which we live. And this is enough. It is of very inferior consequence, by what terms we express our notion, or

rather our admiration, of this attribute. The terms, which the piety and the usage of language have rendered habitual to us, may be as proper as any other. We can trace this attribute much beyond what is necessary for any conclusion to which we have occasion to apply it. The degree of knowledge and power, requisite for the formation of created nature, cannot, with respect to us, be distinguished from infinite.

The Divine "omnipresence" stands, in natural theology, upon this foundation:—In every part and place of the universe with which we are acquainted, we perceive the exertion of a power, which we believe, mediately or immediately, to proceed from the Deity. For instance: in what part or point of space, that has ever been explored, do we not discover attraction? In what regions do we not find light? In what accessible portion of our globe do we not meet with gravity, magnetism, electricity? together with the properties also and powers of organized substances, of vegetable or of animated nature? Nay, farther, we may ask, what kingdom is there of nature, what corner of space, in which there is any thing that can be examined by us, where we do not fall upon contrivance and design? The only reflection perhaps which arises in our minds from this view of the world around us is, that the laws of nature every where prevail; that they are uniform and universal. But what do we mean by the laws of

nature, or by any law, ? Effects are produced by power, not by laws. A law cannot execute itself. A law refers us to an agent. Now an agency so general, as that we cannot discover its absence, or assign the place in which some effect of its continued energy is not found, may, in popular language at least, and, perhaps, without much deviation from philosophical strictness, be called universal: and, with not quite the same, but with no inconsiderable propriety, the Person, or Being, in whom that power resides, or from whom it is derived, may be taken to be *omnipresent.* He who upholds all things by his power, may be said to be every where present.

This is called a virtual presence. There is also what metaphysicians denominate an essential ubiquity; and which idea the language of Scripture seems to favour: but the former, I think, goes as far as natural theology carries us.

"Eternity" is a negative idea, clothed with a positive name. It supposes, in that to which it is applied, a present existence; and is the negation of a beginning or an end of that existence. As applied to the Deity, it has not been controverted by those who acknowledge a Deity at all. Most assuredly, there never was a time in which nothing existed, because that condition must have continued. The universal *blank* must have remained; nothing could rise up out of it; nothing could ever have existed since: nothing could exist now.

In strictness, however, we have no concern with duration prior to that of the visible world. Upon this article, therefore, of theology, it is sufficient to know, that the contriver necessarily existed before the contrivance.

"Self-existence" is another negative idea, viz. the negation of a preceding cause, as of a progenitor, a maker, an author, a creator.

"Necessary existence" means demonstrable existence.

"Spirituality" expresses an idea, made up of a negative part, and of a positive part. The negative part consists in the exclusion of some of the known properties of matter, especially of solidity, of the *vis inertiæ*, and of gravitation. The positive part comprises perception, thought, will, power, *action;* by which last term is meant, the origination of motion; the quality, perhaps, in which resides the essential superiority of spirit over matter, "which cannot move, unless it be moved; and cannot but move, when impelled by another."* I apprehend that there can be no difficulty in applying to the Deity both parts of this idea.

* Bishop Wilkins's Principles of Natural Religion, p. 106.

CHAPTER XXV.

THE UNITY OF THE DEITY.

Of the "Unity of the Deity," the proof is, the *uniformity* of plan observable in the universe. The universe itself is a system; each part either depending upon other parts, or being connected with other parts by some common law of motion, or by the presence of some common substance. One principle of gravitation causes a stone to drop towards the earth, and the moon to wheel round it. One law of attraction carries all the different planets about the sun. This philosophers demonstrate. There are also other points of agreement amongst them, which may be considered as marks of the identity of their origin, and of their intelligent Author. In all are found the conveniency and stability derived from gravitation. They all experience vicissitudes of days and nights, and changes of season. They all, at least Jupiter, Mars, and Venus, have the same advantages from their atmosphere as we have. In all the planets, the axes of rotation are permanent. Nothing is more probable, than that the same attracting influence, acting according to the same rule, reaches to

the fixed stars: but, if this be only probable, another thing is certain, viz. that the same element of light does. The light from a fixed star affects our eyes in the same manner, is refracted and reflected according to the same laws, as the light of a candle. The velocity of the light of the fixed stars is also the same as the velocity of the light of the sun, reflected from the satellites of Jupiter. The heat of the sun, in kind, differs nothing from the heat of a coal fire.

In our own globe, the case is clearer. New countries are continually discovered, but the old laws of nature are always found in them: new plants perhaps, or animals, but always in company with plants and animals which we already know; and always possessing many of the same general properties. We never get amongst such original, or totally different, modes of existence, as to indicate, that we are come into the province of a different Creator, or under the direction of a different will. In truth, the same order of things attends us wherever we go. The elements act upon one another, electricity operates, the tides rise and fall, the magnetic needle elects its position in one region of the earth and sea as well as in another. One atmosphere invests all parts of the globe, and connects all; one sun illuminates, one moon exerts its specific attraction upon all parts. If there be a variety in natural effects, as, *e. g.* in the tides of different seas, that very variety is the

result of the same cause, acting under different circumstances. In many cases this is proved; in all, is probable.

The inspection and comparison of *living* forms, add to this argument examples without number. Of all large terrestrial animals, the structure is very much alike; their senses nearly the same; their natural functions and passions nearly the same; their viscera nearly the same, both in substance, shape, and office: digestion, nutrition, circulation, secretion, go on, in a similar manner, in all: the great circulating fluid is the same; for, I think, no difference has been discovered in the properties of *blood*, from whatever animal it be drawn. The experiment of transfusion* proves, that the blood of one animal will serve for another. The *skeletons* also of the larger terrestrial animals, show particular varieties, but still under a great general affinity. The resemblance is somewhat less, yet sufficiently evident, between quadrupeds and birds. They are all alike in five respects, for one in which they differ.

In *fish*, which belong to another department, as it were, of nature, the points of comparison become

* The experiment has been recently tried, and the principle is rendered extremely doubtful, whether the blood of one animal can be substituted for that of another. The blood of an animal of the same species may with safety be transferred into another animal of the same species; but the transfusion of the blood of an animal of different species generally proves fatal. See Dr. Blundell's experiments on transfusion in Med. Chir. Trans. vol. ix.

fewer. But we never lose sight of our analogy, *e. g.* we still meet with a stomach, a liver, a spine; with bile and blood; with teeth; with eyes, (which eyes are only slightly varied from our own, and which variation, in truth, demonstrates, not an interruption, but a continuance of the same exquisite plan; for it is the adaptation of the organ to the element, viz. to the different refraction of light passing into the eye out of a denser medium.) The provinces, also, themselves of water and earth, are connected by the species of animals which inhabit both; and also by a large tribe of aquatic animals, which closely resemble the terrestrial in their internal structure; I mean the cetaceous* tribe, which have hot blood, respiring lungs, bowels, and other essential parts, like those of land animals. This similitude, surely, bespeaks the same creation and the same Creator.

Insects and *shell-fish* appear to me to differ from other classes of animals the most widely of any. Yet even here, beside many points of particular resemblance, there exists a general relation of a peculiar kind. It is the relation of inversion; the law of contrariety: namely, that whereas, in other animals, the bones to which the muscles are attached and lie *within* the body; in insects and

* This order consists of four genera, viz: the *narwal, whale, cachalot,* and *dolphin;* the whole of which, though inhabiting the ocean, and possessing the habits and manners of *fish,* yet from their similarity of structure, their being viviparous, and giving suck to their young, they necessarily class with the *mammalia.*

shell-fish they lie on the *outside* of it. The shell of a lobster performs to the animal the office of a *bone*, by furnishing to the tendons that fixed basis or immoveable fulcrum, without which, mechanically, they could not act. The crust of an insect is its shell, and answers the like purpose. The shell also of an oyster stands in the place of a *bone;* the basis of the muscles being fixed to it, in the same manner as, in other animals, they are fixed to the bones. All which (under wonderful varieties, indeed, and adaptations of form) confesses an imitation, a remembrance, a carrying on, of the same plan.*

The observations here made are equally applicable to plants; but, I think, unnecessary to be

* If we take a rapid survey of the different animated beings, we may perceive in the more perfect animals, that while the bones of the head and vertebræ are always present, particular classes and orders are destitute of clavicles, sternum, and extremities. But animals possessing a skeleton including those of the most simple form, are few in number in comparison with those whose hard parts are connected with the integuments, as is above noticed of the lobster, &c. or form solid pieces of support, as shell-fish, insects, worms, &c. These circumstances have given rise to an arrangement of animals into two grand divisions; the *vertebral* and *invertebral;* the former possessing a vertebral column of which the latter have none. The honour of forming these divisions is claimed by M. Lamark, in his "Systeme des Animaux sans Vertebres," 8vo. 1801. The vertebral animals include mammalia, birds, reptiles, and fishes; the invertebral, those which were termed by Linnæus insects and worms.

Paley has recognized these primary divisions of the animal kingdom, and has justly observed, that the shell of the invertebral animals, and the crust of an insect serve the purpose in the animal economy of bone, and we would add, the additional purpose of

pursued. It is a very striking circumstance, and alone sufficient to prove all which we contend for, that in this part likewise of organized nature, we perceive a continuation of the *sexual* system.

Certain however it is, that the whole argument for the divine unity, goes no farther than to a unity of counsel.

It may likewise be acknowledged, that no arguments which we are in possession of, exclude the ministry of subordinate agents. If such there be, they act under a presiding, a controlling will; because they act according to certain general restrictions, by certain common rules, and, as it should seem, upon a general plan: but still such agents, and different ranks, and classes, and degrees of them, may be employed.

CHAPTER XXVI.

THE GOODNESS OF THE DEITY.

The proof of the *divine goodness* rests upon two propositions; each, as we contend, capable of

armour, so that, as well as support, it gives protection to the softer parts. Shell is formed by successive depositions of earthy particles, with a portion of animal matter. The covering of insects has a horny character, like the nails, in which the earthy matter is almost absent.

being made out by observations drawn from the appearances of nature.

The first is, "that in a vast plurality of instances in which contrivance is perceived, the design of the contrivance is *beneficial*."

The second, "that the Deity has superadded *pleasure* to animal sensations, beyond what was necessary for any other purpose, or when the purpose, so far as it was necessary, might have been effected by the operation of pain."

First, "in a vast plurality of instances in which contrivance is perceived, the design of the contrivance is *beneficial*."

No productions of nature display contrivance so manifestly as the parts of animals; and the parts of animals have all of them, I believe, a real, and with very few exceptions, all of them a known and intelligible, subserviency to the use of the animal. Now, when the multitude of animals is considered, the number of parts in each, their figure and fitness, the faculties depending upon them, the variety of species, the complexity of structure, the success, in so many cases, and felicity of the result, we can never reflect, without the profoundest adoration, upon the character of that Being from whom all these things have proceeded: we cannot help acknowledging, what an exertion of benevolence creation was; of a benevolence how minute in its care, how vast in its comprehension!

When we appeal to the parts and faculties of

animals, and to the limbs and senses of animals in particular, we state, I conceive, the proper medium of proof for the conclusion which we wish to establish. I will not say that the insensible parts of nature are made solely for the sensitive parts: but this I say, that, when we consider the benevolence of the Deity, we can only consider it in relation to sensitive being. Without this reference, or referred to any thing else, the attribute has no object; the term has no meaning. Dead matter is nothing. The parts, therefore, especially the limbs and senses of animals, although they constitute, in mass and quantity, a small portion of the material creation, yet, since they alone are instruments of perception, they compose what may be called the whole of visible nature, estimated with a view to the disposition of its Author. Consequently, it is in *these* that we are to seek his character. It is by these that we are to prove, that the world was made with a benevolent design.

Nor is the design abortive. It is a happy world after all. The air, the earth, the water, teem with delighted existence. In a spring noon, or a summer evening, on whichever side I turn my eyes, myriads of happy beings crowd upon my view. "The insect youth are on the wing." Swarms of new-born *flies* are trying their pinions in the air. Their sportive motions, their wanton mazes, their gratuitous activity, their continual change of place without use or purpose, testify their joy, and the

exultation which they feel in their lately discovered faculties. A *bee* amongst the flowers in spring, is one of the most cheerful objects that can be looked upon. Its life appears to be all enjoyment; so busy, and so pleased: yet it is only a specimen of insect life, with which, by reason of the animal being half domesticated, we happen to be better acquainted than we are with that of others. The *whole winged* insect tribe, it is probable, are equally intent upon their proper employments, and, under every variety of constitution, gratified, and perhaps equally gratified, by the offices which the Author of their nature has assigned to them. But the atmosphere is not the only scene of enjoyment for the insect race. Plants are covered with aphides, greedily sucking their juices, and constantly, as it should seem, in the act of sucking. It cannot be doubted but that this is a state of gratification. What else should fix them so close to the operation, and so long? Other species are *running about*, with an alacrity in their motions, which carries with it every mark of pleasure. Large patches of ground are sometimes half covered with these brisk and sprightly natures. If we look to what the *waters* produce, shoals of the fry of fish frequent the margins of rivers, of lakes, and of the sea itself. These are so happy, that they know not what to do with themselves. Their attitudes, their vivacity, their leaps out of the water, their frolics in it, (which I have noticed a

thousand times with equal attention and amusement,) all conduce to show their excess of spirits, and are simply the effects of that excess. Walking by the sea-side, in a calm evening, upon a sandy shore, and with an ebbing tide, I have frequently remarked the appearance of a dark cloud, or rather, very thick mist, hanging over the edge of the water, to the height, perhaps, of half a yard, and of the breadth of two or three yards, stretching along the coast as far as the eye could reach, and always retiring with the water. When this cloud came to be examined, it proved to be nothing else than so much space, filled with young *shrimps*, in the act of bounding into the air from the shallow margin of the water, or from the wet sand. If any motion of a mute animal could express delight, it was this: if they had meant to make signs of their happiness, they could not have done it more intelligibly. Suppose then, what I have no doubt of, each individual of this number to be in a state of positive enjoyment; what a sum, collectively, of gratification and pleasure have we here before our view!

The *young* of all animals appear to me to receive pleasure simply from the exercise of their limbs and bodily faculties, without reference to any end to be attained, or any use to be answered by the exertion. A child, without knowing any thing of the use of language, is in a high degree delighted with being able to speak. Its incessant

repetition of a few articulate sounds, or perhaps of the single word which it has learned to pronounce, proves this point clearly. Nor is it less pleased with its first successful endeavours to walk, or rather to run, (which precedes walking,) although entirely ignorant of the importance of the attainment to its future life, and even without applying it to any present purpose. A child is delighted with speaking, without having any thing to say; and with walking, without knowing where to go. And, prior to both these, I am disposed to believe, that the waking hours of infancy are agreeably taken up with the exercise of vision, or perhaps, more properly speaking, with learning to see.

But it is not for youth alone that the great Parent of creation hath provided. Happiness is found with the purring cat, no less than with the playful kitten; in the arm-chair of dozing age, as well as in either the sprightliness of the dance, or the animation of the chase. To novelty, to acuteness of sensation, to hope, to ardour of pursuit, succeeds what is, in no inconsiderable degree, an equivalent for them all, "perception of ease." Herein is the exact difference between the young and the old. The young are not happy, but when enjoying pleasure; the old are happy, when free from pain. And this constitution suits with the degrees of animal power which they respectively possess. The vigour of youth was to be stimulated to action by impatience of rest; whilst to the imbecility of

age, quietness and repose become positive gratifications. In one important respect the advantage is with the old. A state of ease is, generally speaking, more attainable than a state of pleasure. A constitution therefore which can enjoy ease, is preferable to that which can taste only pleasure. The same perception of ease oftentimes renders old age a condition of great comfort; especially when riding at its anchor after a busy or tempestuous life. It is well described by Rousseau, to be the interval of repose and enjoyment, between the hurry and the end of life. How far the same cause extends to other animal natures cannot be judged of with certainty. The appearance of satisfaction, with which most animals, as their activity subsides, seek and enjoy rest, affords reason to believe, that this source of gratification is appointed to advanced life, under all, or most, of its various forms. In the species with which we are best acquainted, namely, our own, I am far, even as an observer of human life, from thinking that youth is its happiest season, much less the only happy one: as a Christian, I am willing to believe that there is a great deal of truth in the following representation, given by a very pious writer, as well as an excellent man:* "To the intelligent and virtuous, old age presents a scene of tranquil enjoyments, of obedient appetite, of well-regulated affections, of maturity in knowledge, and of calm

* Father's Instructions; by Dr. Percival of Manchester, p. 317.

preparation for immortality. In this serene and dignified state, placed as it were on the confines of two worlds, the mind of a good man reviews what is past with the complacency of an approving conscience; and looks forward with humble confidence in the mercy of God, and with devout aspirations towards his eternal and ever-increasing favour."

What is seen in different stages of the same life, is still more exemplified in the lives of different animals. Animal enjoyments are infinitely *diversified*. The modes of life to which the organization of different animals respectively determines them, are not only of various but of opposite kinds. Yet each is happy in its own. For instance; animals of prey live much alone; animals of a milder constitution, in society. Yet the herring, which lives in shoals, and the sheep, which lives in flocks, are not more happy in a crowd, or more contented amongst their companions, than is the pike, or the lion, with the deep solitudes of the pool, or the forest.

But it will be said, that the instances which we have here brought forward, whether of vivacity or repose, or of apparent enjoyment derived from either, are picked and favourable instances. We answer, first, that they are instances, nevertheless, which comprise large provinces of sensitive existence; that every case which we have described, is the case of millions. At this moment, in every given moment of time, how many myriads of ani-

mals are eating their food, gratifying their appetites, ruminating in their holes, accomplishing their wishes, pursuing their pleasures, taking their pastimes! In each individual, how many things must go right for it to be at ease; yet how large a proportion out of every species is so in every assignable instant! Secondly, we contend, in the terms of our original proposition, that throughout the whole of life, as it is diffused in nature, and as far as we are acquainted with it, looking to the average of sensations, the plurality and the preponderancy is in favour of happiness by a vast excess. In our own species, in which perhaps the assertion may be more questionable than in any other, the prepollency of good over evil, of health, for example, and ease, over pain and distress, is evinced by the very notice which calamities excite. What inquiries does the sickness of our friends produce! What conversation their misfortunes! This shows that the common course of things is in favour of happiness; that happiness is the rule, misery the exception. Were the order reversed, our attention would be called to examples of health and competency, instead of disease and want.

One great cause of our insensibility to the goodness of the Creator, is the very *extensiveness* of his bounty. We prize but little what we share only in common with the rest, or with the generality of our species. When we hear of blessings, we think forthwith of successes, of prosperous

fortunes, of honours, riches, preferments; *i. e.* of those advantages and superiorities over others, which we happen either to possess, or to be in pursuit of, or to covet. The common benefits of our nature entirely escape us. Yet these are the great things. These constitute what most properly ought to be accounted blessings of Providence; what alone, if we might so speak, are worthy of its care. Nightly rest and daily bread, the ordinary use of our limbs, and senses, and understandings, are gifts which admit of no comparison with any other. Yet, because almost every man we meet with possesses these, we leave them out of our enumeration. They raise no sentiment: they move no gratitude. Now herein is our judgment perverted by our selfishness. A blessing ought in truth to be the *more* satisfactory, the bounty at least of the donor is rendered more conspicuous, by its very diffusion, its commonness, its cheapness; by its falling to the lot, and forming the happiness, of the great bulk and body of our species, as well as of ourselves. Nay, even when we do not possess it, it ought to be matter of thankfulness that others do. But we have a different way of thinking. We court distinction. That is not the worst: we *see* nothing but what has distinction to recommend it. This necessarily contracts our views of the Creator's beneficence within a narrow compass; and most unjustly. It is in those things which are so common as to be no

distinction, that the amplitude of the divine benignity is perceived.

But pain, no doubt, and privations exist, in numerous instances, and to a degree which collectively, would be very great, if they were compared with any other thing than with the mass of animal fruition. For the application, therefore, of our proposition to that *mixed* state of things which these exceptions induce, two rules are necessary, and both, I think, just and fair rules. One is, that we regard those effects alone which are accompanied with proofs of intention: the other, that when we cannot resolve all appearances into benevolence of design, we make the few give place to the many; the little to the great; that we take our judgment from a large and decided preponderancy, if there be one.

I crave leave to transcribe into this place, what I have said upon this subject in my Moral Philosophy:—

"When God created the human species, either he wished their happiness, or he wished their misery, or he was indifferent and unconcerned about either.

"If he had wished our misery, he might have made sure of his purpose, by forming our senses to be so many sores and pains to us, as they are now instruments of gratification and enjoyment: or by placing us amidst objects so ill suited to our perceptions, as to have continually offended us, instead

of ministering to our refreshment and delight. He might have made, for example, every thing we tasted, bitter; every thing we saw, loathsome; every thing we touched, a sting; every smell, a stench; and every sound, a discord.

"If he had been indifferent about our happiness or misery, we must impute to our good fortune (as all design by this supposition is excluded) both the capacity of our senses to receive pleasure, and the supply of external objects fitted to produce it.

"But either of these, and still more both of them, being too much to be attributed to accident, nothing remains but the first supposition, that God, when he created the human species, wished their happiness; and made for them the provision which he has made, with that view and for that purpose.

"The same argument may be proposed in different terms; *thus:* contrivance proves design: and the predominant tendency of the contrivance indicates the disposition of the designer. The world abounds with contrivances: and all the contrivances which we are acquainted with, are directed to beneficial purposes. Evil, no doubt, exists; but is never, that we can perceive, the *object* of contrivance. Teeth are contrived to eat, not to ache; their aching now and then is incidental to the contrivance, perhaps inseparable from it: or even, if you will, let it be called a defect in the contrivance; but it is not the object

of it. This is a distinction which well deserves to be attended to. In describing implements of husbandry, you would hardly say of the sickle, that it is made to cut the reaper's hand; though, from the construction of the instrument, and the manner of using it, this mischief often follows. But if you had occasion to describe instruments of torture or execution: this engine, you would say, is to extend the sinews; this to dislocate the joints; this to break the bones; this to scorch the soles of the feet. Here pain and misery are the very objects of the contrivance. Now, nothing of this sort is to be found in the works of nature. We never discover a train of contrivance to bring about an evil purpose. No anatomist ever discovered a system of organization calculated to produce pain and disease; or, in explaining the parts of the human body, ever said, this is to irritate; this to inflame; this duct is to convey the gravel to the kidneys; this gland to secrete the humour which forms the gout: if by chance he come at a part of which he knows not the use, the most he can say is, that it is useless; no one ever suspects that it is put there to incommode, to annoy, or to torment."

The TWO CASES which appear to me to have the most of difficulty in them, as forming the most of the appearance of exception to the representation here given, are those of *venomous* animals, and of animals *preying* upon one another. These pro-

perties of animals, wherever they are found, must, I think, be referred to design; because there is, in all cases of the first, and in most cases of the second, an express and distinct organization provided for the producing of them. Under the first head, the fangs of vipers, the stings of wasps and scorpions, are as clearly intended for their purpose, as any animal structure is for any purpose the most incontestably beneficial. And the same thing must, under the second head, be acknowledged of the talons and beaks of birds, of the tusks, teeth, and claws of beasts of prey, of the shark's mouth, of the spider's web, and of numberless weapons of offence belonging to different tribes of voracious insects. We cannot, therefore, avoid the difficulty by saying, that the effect was not intended. The only question open to us is, whether it be ultimately evil. From the confessed and felt imperfection of our knowledge, we ought to presume, that there may be consequences of this economy which are hidden from us: from the benevolence which pervades the general designs of nature, we ought also to presume, that these consequences, if they could enter into our calculation, would turn the balance on the favourable side. Both these I contend to be reasonable presumptions. Not reasonable presumptions, if these two cases were the only cases which nature presented to our observation; but reasonable presumptions under the reflection, that the cases

in question are combined with a multitude of intentions, all proceeding from the same author, and all, except these, directed to ends of undisputed utility. Of the vindications, however, of this economy, which we are able to assign, such as most extenuate the difficulty, are the following.

With respect to *venomous* bites and stings, it may be observed,—

1. That the animal itself being regarded, the faculty complained of is *good:* being conducive, in all cases, to the defence of the animal; in some cases, to the subduing of its prey; and in some, probably, to the killing of it, when caught, by a mortal wound, inflicted in the passage to the stomach, which may be no less merciful to the victim than salutary to the devourer. In the viper, for instance, the poisonous fang may do that which, in other animals of prey, is done by the crush of the teeth. Frogs and mice might be swallowed alive without it.

2. But it will be said, that this provision, when it comes to the case of bites, deadly even to human bodies and to those of large quadrupeds, is greatly *overdone;* that it might have fulfilled its use, and yet have been much less deleterious than it is. Now I believe the case of bites, which produce death in large animals (of stings I think there are none) to be very few. The experiments of the Abbe Fontana, which were numerous, go strongly to the proof of this point. He found that it re-

quired the action of five exasperated vipers to kill a dog of a moderate size; but that, to the killing of a mouse or a frog, a single bite was sufficient; which agrees with the use which we assign to the faculty. The Abbe seemed to be of opinion, that the bite even of the rattle-snake would not usually be mortal; allowing, however, that in certain particularly unfortunate cases, as when the puncture had touched some very tender part, pricked a principal nerve for instance, or, as it is said, some more considerable lymphatic vessel, death might speedily ensue.

3. It has been, I think, very justly remarked, concerning serpents, that, whilst only a few species possess the venomous property, that property guards the whole tribe. The most innocuous snake is avoided with as much care as a viper. Now the terror with which large animals regard this class of reptiles, is its protection; and this terror is founded in the formidable revenge which a few of the number, compared with the whole, are capable of taking. The species of serpents, described by Linnæus, amount to two hundred and eighteen, of which thirty-two only are poisonous.

4. It seems to me, that animal constitutions are provided, not only for each element, but for each state of the elements, *i.e.* for every climate, and for every temperature; and that part of the mischief complained of, arises from animals (the hu-

man animal most especially) occupying situations upon the earth which do not belong to them, nor were ever intended for their habitation. The folly and wickedness of mankind, and necessities proceeding from these causes, have driven multitudes of the species to seek a refuge amongst burning sands, whilst countries, blessed with hospitable skies, and with the most fertile soils, remain almost without a human tenant. We invade the territories of wild beasts and venomous reptiles, and then complain that we are infested by their bites and stings. Some accounts of Africa place this observation in a strong point of view. "The deserts," says Adanson, "are entirely barren, except where they are found to produce serpents; and in such quantities, that some extensive plains are almost entirely covered with them." These are the natures appropriated to the situation. Let them enjoy their existence; let them have their country. Surface enough will be left to man, though his numbers were increased a hundred-fold, and left to him, where he might live exempt from these annoyances.

The SECOND CASE, viz. that of animals *devouring* one another, furnishes a consideration of much larger extent. To judge whether, as a general provision, this can be deemed an *evil*, even so far as we understand its consequences, which, probably, is a partial understanding, the following reflections are fit to be attended to.

1. Immortality upon this earth is out of the question. Without death there could be no generation, no sexes, no parental relation, *i. e.* as things are constituted, no animal happiness. The particular duration of life, assigned to different animals, can form no part of the objection; because, whatever that duration be, whilst it remains finite and limited, it may always be asked, why it is no longer. The natural age of different animals varies, from a single day to a century of years. No account can be given of this; nor could any be given, whatever other proportion of life had obtained amongst them.

The term then of life in different animals being the same as it is, the question is, what mode of taking it away is the best even for the animal itself?

Now, according to the established order of nature, (which we must suppose to prevail, or we cannot reason at all upon the subject,) the three methods by which life is usually put an end to, are acute diseases, decay, and violence. The simple and natural life of *brutes*, is not often visited by acute distempers; nor could it be deemed an improvement of their lot, if they were. Let it be considered, therefore, in what a condition of suffering and misery a brute animal is placed, which is left to perish by *decay*. In human sickness or infirmity, there is the assistance of man's rational fellow-creatures, if not to alleviate his pains, at

least to minister to his necessities, and to supply the place of his own activity. A brute, in his wild and natural state, does every thing for himself. When his strength, therefore, or his speed, or his limbs, or his senses fail him, he is delivered over, either to absolute famine, or to the protracted wretchedness of a life slowly wasted by the scarcity of food. Is it then to see the world filled with drooping, superannuated, half-starved, helpless, and unhelped animals, that you would alter the present system of pursuit and prey?

2. Which system is also to them the spring of motion and activity on both sides. The pursuit of its prey forms the employment, and appears to constitute the pleasure, of a considerable part of the animal creation. The using of the means of defence, or flight, or precaution, forms also the business of another part. And even of this latter tribe, we have no reason to suppose, that their happiness is much molested by their fears. Their danger exists continually; and in some cases they seem to be so far sensible of it, as to provide in the best manner they can against it; but it is only when the attack is actually made upon them, that they appear to suffer from it. To contemplate the insecurity of their condition with anxiety and dread, requires a degree of reflection, which (happily for themselves) they do not possess. A *hare*, notwithstanding the number of its dangers and its enemies, is as playful an animal as any other.

3. But, to do justice to the question, the system of animal *destruction* ought always to be considered in strict connexion with another property of animal nature, viz. *superfecundity*. They are countervailing qualities. One subsists by the correction of the other. In treating, therefore, of the subject under this view, (which is, I believe, the true one,) our business will be, first, to point out the advantages which are gained by the powers in nature of a superabundant multiplication; and then to show, that these advantages are so many reasons for appointing that system of national hostilities, which we are endeavouring to account for.

In almost all cases, nature produces her supplies with profusion. A single cod-fish spawns, in one season, a greater number of eggs than all the inhabitants of England amount to. A thousand other instances of prolific generation might be stated, which, though not equal to this, would carry on the increase of the species with a rapidity which outruns calculation, and to an immeasurable extent. The advantages of such a constitution are two: first, that it tends to keep the world always full: whilst, secondly, it allows the proportion between the several species of animals to be differently modified, as different purposes require, or as different situations may afford for them room and food. Where this vast fecundity meets with a vacancy fitted to receive the species, there it operates with its whole effect; there it pours in

its numbers, and replenishes the waste. We complain of what we call the exorbitant multiplication of some troublesome insects; not reflecting, that large portions of nature might be left void without it. If the accounts of travellers may be depended upon, immense tracts of forest in North America would be nearly lost to sensitive existence, if it were not for *gnats*. "In the thinly inhabited regions of America, in which the waters stagnate and the climate is warm, the whole air is filled with crowds of these insects." Thus it is, that where we looked for solitude and death-like silence, we meet with animation, activity, enjoyment; with a busy, a happy, and a peopled world. Again; hosts of *mice* are reckoned amongst the plagues of the north-east part of Europe; whereas vast plains in Siberia, as we learn from good authority, would be lifeless without them. The Caspian deserts are converted by their presence into crowded warrens. Between the Volga and the Yaik, and in the country of Hyrcania, the ground, says Pallas, is in many places *covered* with little hills, raised by the earth cast out in forming the burrows. Do we so envy these blissful abodes, as to pronounce the fecundity by which they are supplied with inhabitants, to be an evil; a subject of complaint, and not of praise? Farther; by virtue of this same superfecundity, what we term destruction, becomes almost instantly the parent of life. What we call blights, are oftentimes legions of animated beings,

claiming their portion in the bounty of nature. What corrupts the produce of the earth to us, prepares it for them. And it is by means of their rapid multiplication, that they take possession of their pasture; a slow propagation would not meet the opportunity.

But in conjunction with the occasional use of this fruitfulness, we observe, also, that it allows the proportion between the several species of animals to be differently modified, as different purposes of utility may require. When the forests of America come to be cleared, and the swamps drained, our gnats will give place to other inhabitants. If the population of Europe should spread to the north and the east, the mice will retire before the husbandman and the shepherd, and yield their station to herds and flocks. In what concerns the human species, it may be a part of the scheme of Providence, that the earth should be inhabited by a shifting, or perhaps a circulating population. In this economy, it is possible that there may be the following advantages: when old countries are become exceedingly corrupt, simpler modes of life, purer morals, and better institutions, may rise up in new ones, whilst fresh soils reward the cultivator with more plentiful returns. Thus the different portions of the globe come into use in succession as the residence of man; and, in his absence, entertain other guests, which, by their sudden multiplication, fill the chasm. In domesticated

animals, we find the effect of their fecundity to be, that we can always command *numbers;* we can always have as many of any particular species as we please, or as we can support. Nor do we complain of its excess; it being much more easy to regulate abundance, than to supply scarcity.

But then this *superfecundity*, though of great occasional use and importance, exceeds the ordinary capacity of nature to receive or support its progeny. All superabundance supposes destruction, or must destroy itself. Perhaps there is no species of terrestrial animals whatever, which would not overrun the earth, if it were permitted to multiply in perfect safety; or of fish, which would not fill the ocean: at least, if any single species were left to their natural increase without disturbance or restraint, the food of other species would be exhausted by their maintenance. It is necessary, therefore that the effects of such prolific faculties be curtailed. In conjunction with other checks and limits, all subservient to the same purpose, are the *thinnings* which take place among animals, by their action upon one another. In some instances we ourselves experience, very directly, the use of these hostilities. One species of insects rids us of another species; or reduces their ranks. A third species, perhaps, keeps the second within bounds; and birds or lizards are a fence against the inordinate increase by which even these last might infest us. In other more

numerous, and possibly more important instances, this disposition of things, although less necessary or useful to us, and of course less observed by us, may be necessary and useful to certain other species; or even for the preventing of the loss of certain species from the universe: a misfortune which seems to be studiously guarded against. Though there may be the appearance of failure in some of the details of Nature's works, in her great purposes there never are. Her species never fail. The provision which was originally made for continuing the replenishment of the world, has proved itself to be effectual through a long succession of ages.

What farther shows, that the system of destruction amongst animals holds an express relation to the system of fecundity; that they are parts indeed of one compensatory scheme; is, that in each species the fecundity bears a proportion to the smallness of the animal, to the weakness, to the shortness of its natural term of life, and to the dangers and enemies by which it is surrounded. An elephant produces but one calf; a butterfly lays siz hundred eggs. Birds of prey seldom produce more than two eggs: the sparrow tribe, and the duck tribe, frequently sit upon a dozen. In the rivers, we meet with a thousand minnows for one pike; in the sea a million of herrings for a single shark. Compensation obtains throughout. Defencelessness and devastation are repaired by fecundity.

We have dwelt the longer on these considerations, because the subject to which they apply, namely, that of animals *devouring* one another, forms the chief, if not the only instance, in the works of the Deity, of an economy, stamped by marks of design, in which the character of utility can be called in question. The case of *venomous* animals is of much inferior consequence to the case of prey, and in some degree is also included under it. To both cases, it is probable that many more reasons belong, than those of which we are in possession.

Our FIRST PROPOSITION, and that which we have hitherto been defending, was, "that, in a vast plurality of instances in which *contrivance* is perceived, the design of the contrivance is beneficial."

Our SECOND PROPOSITION is, "that the Deity has added *pleasure* to animal sensations, beyond what was necessary for any other purpose, or when the purpose, so far as it was necessary, might have been effected by the operation of pain."

This proposition may be thus explained: the capacities, which, according to the established course of nature, are *necessary* to the support or preservation of an animal, however manifestly they may be the result of an organization contrived for the purpose, can only be deemed an act or a part of the same will, as that which decreed the existence of the animal itself; because, whether the

creation proceeded from a benevolent or a malevolent being, these capacities must have been given, if the animal existed at all. Animal properties, therefore, which fall under this description, do not strictly prove the goodness of God: they may prove the existence of the Deity; they may prove a high degree of power and intelligence: but they do not prove his goodness; forasmuch as they must have been found in any creation which was capable of continuance, although it is possible to suppose, that such a creation might have been produced by a being whose views rested upon misery.

But there is a class of properties, which may be said to be superadded from an intention expressly directed to happiness; an intention to give a happy existence distinct from the general intention of providing the means of existence; and that is, of capacities for pleasure, in cases wherein, so far as the conservation of the individual or of the species is concerned, they were not wanted, or wherein the purpose might have been secured by the operation of pain. The provision which is made of a variety of objects, not necessary to life, and ministering only to our pleasures; and the properties given to the necessaries of life themselves, by which they contribute to pleasure as well as preservation; show a farther design than that of giving existence.*

* See this topic considered in Dr. Balguy's Treatise upon the

A single instance will make all this clear. Assuming the necessity of food for the support of animal life; it is requisite, that the animal be provided with organs, fitted for the procuring, receiving and digesting of its food. It may also be necessary, that the animal be impelled by its sensations to exert its organs. But the pain of hunger would do all this. Why add pleasure to the act of eating; sweetness and relish to food? why a new and appropriate sense for the perception of the pleasure? Why should the juice of a peach, applied to the palate, affect the part so differently from what it does when rubbed upon the palm of the hand? This is a constitution which, so far as appears to me, can be resolved into nothing but the pure benevolence of the Creator. Eating is necessary; but the pleasure attending it is not necessary; and that this pleasure depends, not only upon our being in possession of the sense of taste, which is different from every other, but upon a particular state of the organ in which it resides, a felicitous adaptation of the organ to the object, will be confessed by any one, who may happen to have experienced that vitiation of taste which frequently occurs in fevers, when every taste is irregular, and every one bad.

Divine Benevolence. This excellent author, first, I think, proposed it; and nearly in the terms in which it is here stated. Some other observations also under this head are taken from that Treatise.

In mentioning the gratifications of the palate, it may be said, that we have made choice of a trifling example. I am not of that opinion. They afford a share of enjoyment to man: but to brutes, I believe that they are of very great importance. A horse at liberty passes a great part of his waking hours in eating. To the ox, the sheep, the deer, and other ruminating animals, the pleasure is doubled. Their whole time almost is divided between browsing upon their pasture and chewing their cud. Whatever the pleasure be, it is spread over a large portion of their existence. If there be animals, such as the lupous fish, which swallow their prey whole, and at once, without any time, as it should seem, for either drawing out, or relishing the taste in the mouth, is it an improbable conjecture, that the seat of taste with them is in the stomach? or, at least that a sense of pleasure, whether it be taste or not, accompanies the dissolution of the food in that receptacle, which dissolution in general is carried on very slowly? If this opinion be right, they are more than repaid for the defect of palate. The feast lasts as long as the digestion.

In seeking for argument, we need not stay to insist upon the comparative importance of our example; for the observation holds equally of all, or of three, at least, of the other senses. The necessary purposes of hearing might have been answered without harmony; of smell, without

fragrance; of vision, without beauty. Now, "if the Deity had been indifferent about our happiness or misery, we must impute to our good fortune (as all design by this supposition is excluded), both the capacity of our senses to receive pleasure, and the supply of external objects fitted to excite it." I allege these as *two* felicities, for they are different things, yet both necessary: the sense being formed, the objects which were applied to it might not have suited it; the objects being fixed, the sense might not have agreed with them. A coincidence is here required, which no accident can account for. There are three possible suppositions upon the subject, and no more. The first; that the sense, by its original constitution, was made to suit the object: the second; that the object, by its original constitution, was made to suit the sense: the third; that the sense is so constituted, as to be able, either universally, or within certain limits, by habit and familiarity, to render every object pleasant. Whichever of these suppositions we adopt, the effect evinces, on the part of the Author of Nature, a studious benevolence. If the pleasures which we derive from any of our senses depend upon an original congruity between the sense and the properties perceived by it, we know by experience, that the adjustment demanded, with respect to the qualities which were conferred upon the objects that surround us, not only choice and selection, out of a boundless

variety of possible qualities with which these objects might have been endued, but a *proportioning also of degree*, because an excess or defect of intensity spoils the perception, as much almost as an error in the kind and nature of the quality. Likewise the degree of dulness or acuteness in the sense itself, is no arbitrary thing, but in order to preserve the congruity here spoken of, requires to be in an exact or near correspondency with the strength of the impression. The dulness of the senses forms the complaint of old age. Persons in fevers, and, I believe, in most maniacal cases, experience great torment from their preternatural acuteness. An increased, no less than an impaired sensibility, induces a state of disease and suffering.

The doctrine of a specific congruity between animal senses and their objects, is strongly favoured by what is observed of insects in the selection of their food. Some of these will feed upon one kind of plant or animal, and upon no other: some caterpillars upon the cabbage alone; some upon the black currant alone. The species of caterpillar which eats the vine, will starve upon the elder; nor will that which we find upon fennell touch the rose-bush. Some insects confine themselves to two or three kinds of plants or animals. Some again show so strong a preference, as to afford reason to believe, that, though they may be driven by hunger to others, they are led by the pleasure of taste to a few particular plants alone:

and all this, as it should seem, independently of habit or imitation.

But should we accept the third hypothesis, and even carry it so far, as to ascribe every thing which concerns the question to habit, (as in certain species, the human species most particularly, there is reason to attribute something,) we have then before us an animal capacity, not less perhaps to be admired than the native congruities which the other scheme adopts. It cannot be shown to result from any fixed necessity in nature, that what is frequently applied to the senses should of course become agreeable to them. It is, so far as it subsists, a power of accommodation provided in these senses by the Author of their structure, and forms a part of their perfection.

In whichever way we regard the senses, they appear to be specific gifts, ministering, not only to preservation, but to pleasure. But what we usually call the *senses* are probably themselves far from being the only vehicles of enjoyment, or the whole of our constitution which is calculated for the same purpose. We have many internal sensations of the most agreeable kind, hardly referable to any of the five senses. Some physiologists have holden, that all secretion is pleasurable; and that the complacency which in health, without any external assignable object to excite it, we derive from life itself, is the effect of our secretions going on well within us. All this may be true, but if true, what reason

can be assigned for it, except the will of the Creator? It may reasonably be asked, why is any thing a pleasure? and I know no answer which can be returned to the question, but that which refers it to appointment.

We can give no account whatever of our pleasures in the simple and original perception; and, even when physical sensations are assumed, we can seldom account for them in the secondary and complicated shapes in which they take the name of diversions. I never yet met with a sportsman, who could tell me in what the sport consisted; who could resolve it into its principle, and state that principle. I have been a great follower of fishing myself, and in its cheerful solitude have passed some of the happiest hours of a sufficiently happy life; but to this moment, I could never trace out the source of the pleasure which it afforded me.

The "quantum in rebus inane!" whether applied to our amusements or to our graver pursuits, (to which in truth it sometimes equally belongs,) is always an unjust complaint. If trifles engage, and if trifles make us happy, the true reflection suggested by the experiment, is upon the tendency of nature to gratification and enjoyment; which is, in other words, the goodness of its Author towards his sensitive creation.

Rational natures also, as such, exhibit qualities which help to confirm the truth of our position.

The degree of understanding found in mankind, is usually much greater than what is necessary for mere preservation. The pleasure of choosing for themselves, and of prosecuting the object of their choice, should seem to be an original source of enjoyment. The pleasures received from things, great, beautiful, or new, from imitation, or from the liberal arts, are in some measure not only superadded, but unmixed, gratifications, having no pains to balance them.*

I do not know whether our attachment to *property* be not something more than the mere dictate of reason, or even than the mere effect of association. Property communicates a charm to whatever is the object of it. It is the first of our abstract ideas; it cleaves to us the closest and the longest. It endears to the child its plaything, to the peasant his cottage, to the landholder his estate. It supplies the place of prospect and scenery. Instead of coveting the beauty of distant situations, it teaches every man to find it in his own. It gives boldness and grandeur to plains and fens, tinge and colouring to clays and fallows.

All these considerations come in aid of our *second* proposition. The reader will now bear in mind what our two propositions were. They were, firstly, that in a vast plurality of instances in which contrivance is perceived, the design of the

* Balguy on the Divine Benevolence.

contrivance is beneficial: secondly, that the Deity has added pleasure to animal sensations beyond what was necessary for any other purpose; or when the purpose, so far as it was necessary, might have been effected by the operation of pain.

Whilst these propositions can be maintained, we are authorized to ascribe to the Deity the character of benevolence: and what is benevolence at all, must in him be *infinite* benevolence, by reason of the infinite, that is to say, the incalculably great number of objects upon which it is exercised.

Of the ORIGIN OF EVIL, no universal solution has been discovered; I mean, no solution which reaches to all cases of complaint. The most comprehensive is that which arises from the consideration of *general rules*. We may, I think, without much difficulty, be brought to admit the four following points: first, that important advantages may accrue to the universe from the order of nature proceeding according to general laws: secondly, that general laws, however well set and constituted, often thwart and cross one another: thirdly, that from these thwartings and crossings, frequent particular inconveniencies will arise: and, fourthly, that it agrees with our observation to suppose, that some degree of these inconveniences takes place in the works of nature. These points may be allowed; and it may also be asserted, that the general laws with which we are acquainted, are

directed to beneficial ends. On the other hand, with many of these laws we are not acquainted at all, or we are totally unable to trace them in their branches, and in their operation; the effect of which ignorance is, that they cannot be of importance to us as measures by which to regulate our conduct. The conservation of them may be of importance in other respects, or to other beings, but we are uninformed of their value or use; uninformed, consequently, when, and how far, they may or may not be suspended, or their effects turned aside, by a presiding and benevolent will, without incurring greater evils than those which would be avoided. The consideration, therefore, of general laws, although it may concern the question of the origin of evil very nearly, (which I think it does,) rests in views disproportionate to our faculties, and in a knowledge which we do not possess. It serves rather to account for the obscurity of the subject, than to supply us with distinct answers to our difficulties. However, whilst we assent to the above-stated propositions as principles, whatever uncertainty we may find in the application, we lay a ground for believing, that cases of apparent evil, for which *we* can suggest no particular reason, are governed by reasons, which are more general, which lie deeper in the order of second causes, and which on that account are removed to a greater distance from us.

The doctrine of *imperfections*, or, as it is called,

of evils of imperfection, furnishes an account, founded, like the former, in views of universal nature. The doctrine is briefly this:—It is probable, that creation may be better replenished by sensitive beings of different sorts, than by sensitive beings all of one sort. It is likewise probable, that it may be better replenished by different orders of beings rising one above another in gradation, than by beings possessed of equal degrees of perfection. Now, a gradation of such beings, implies a gradation of imperfections. No class can justly complain of the imperfections which belong to its place in the scale, unless it were allowable for it to complain that a scale of being was appointed in nature; for which appointment there appear to be reasons of wisdom and goodness.

In like manner, *finiteness*, or what is resolvable into finiteness, in inanimate subjects, can never be a just subject of complaint, because if it were ever so, it would be always so: we mean, that we can never reasonably demand that things should be larger or more, when the same demand might be made, whatever the quantity or number was.

And to me it seems, that the sense of mankind has so far acquiesced in these reasons, as that we seldom complain of evils of this class, when we clearly perceive them to be such. What I have to add, therefore, is, that we ought not to complain of some other evils which stand upon the same foot of vindication as evils of confessed imperfection.

We never complain, that the globe of our earth is too small; nor should we complain, if it were even much smaller. But where is the difference to us, between a less globe, and part of the present being uninhabitable? The inhabitants of an island may be apt enough to murmur at the sterility of some parts of it, against its rocks, or sands, or swamps; but no one thinks himself authorized to murmur, simply because the island is not larger than it is. Yet these are the same griefs.

The above are the two metaphysical answers which have been given to this great question. They are not the worse for being metaphysical, provided they be founded (which I think they are) in right reasoning: but they are of a nature too wide to be brought under our survey, and it is often difficult to apply them in the detail. Our speculations, therefore, are perhaps better employed when they confine themselves within a narrower circle.

The observations which follow, are of this more limited, but more determinate, kind.

Of *bodily pain*, the principal observation, no doubt, is that which we have already made, and already dwelt upon, viz. "that it is seldom the object of contrivance; that when it is so, the contrivance rests ultimately in good."

To which, however, may be added, that the annexing of pain to the means of destruction is a salutary provision; inasmuch as it teaches vigi-

lance and caution; both gives notice of danger, and excites those endeavours which may be necessary to preservation. The evil consequence which sometimes arises from the want of that timely intimation of danger which pain gives, is known to the inhabitants of cold countries by the example of frost-bitten limbs. I have conversed with patients who have lost toes and fingers by this cause. They have in general told me, that they were totally unconscious of any local uneasiness at the time. Some I have heard declare, that whilst they were about their employment, neither their situation, nor the state of the air was unpleasant. They felt no pain; they suspected no mischief; till, by the application of warmth, they discovered, too late, the fatal injury which some of their extremities had suffered. I say that this shows the use of pain, and that we stand in need of such a monitor. I believe also, that the use extends farther than we suppose, or can now trace; that to disagreeable sensations we, and all animals, owe, or have owed, many habits of action which are salutary, but which are become so familiar, as not easily to be referred to their origin.

Pain also itself is not without its *alleviations*. It may be violent and frequent; but it is seldom both violent and long-continued: and its pauses and intermissions become positive pleasures. It

has the power of shedding a satisfaction over intervals of ease, which I believe few enjoyments exceed. A man resting from a fit of the stone or gout, is, for the time, in possession of feelings which undisturbed health cannot impart. They may be dearly bought, but still they are to be set against the price. And indeed it depends upon the duration and urgency of the pain, whether they be dearly bought or not. I am far from being sure, that a man is not a gainer by suffering a moderate interruption of bodily ease for a couple of hours out of the four-and-twenty. Two very common observations favour this opinion: one is, that remissions of pain call forth, from those who experience them, stronger expressions of satisfaction and of gratitude towards both the author and the instruments of their relief, than are excited by advantages of any other kind: the second is, that the spirits of sick men do not sink in proportion to the acuteness of their sufferings; but rather appear to be roused and supported, not by pain, but by the high degree of comfort which they derive from its cessation, or even its subsidency, whenever that occurs; and which they taste with a relish that diffuses some portion of mental complacency over the whole of that mixed state of sensations in which disease has placed them.

In connexion with bodily pain may be considered bodily *disease*, whether painful or not. Few

diseases are fatal. I have before me the account of a dispensary in the neighbourhood, which states six years' experience as follows:

Admitted	6420
Cured	5476
Dead	234

And this I suppose nearly to agree with what other similar institutions exhibit. Now, in all these cases, some disorder must have been felt, or the patients would not have applied for a remedy; yet we see how large a proportion of the maladies which were brought forward, have either yielded to proper treatment, or, what is more probable, ceased of their own accord. We owe these frequent recoveries, and where recovery does not take place, this patience of the human constitution under many of the distempers by which it is visited, to two benefactions of our nature. One is, that she works within certain limits; allows of a certain latitude within which health may be preserved, and within the confines of which it only suffers a graduated diminution. Different quantities of food, different degrees of exercise, different portions of sleep, different states of the atmosphere, are compatible with the possession of health. So likewise it is with the secretions and excretions, with many internal functions of the body, and with the state, probably, of most of its internal organs. They may vary considerably, not only

without destroying life, but without occasioning any high degree of inconveniency. The other property of our nature, to which we are still more beholden, is its constant endeavour to restore itself, when disordered, to its regular course. The fluids of the body appear to possess a power of separating and expelling any noxious substance which may have mixed itself with them. This they do in eruptive fevers, by a kind of despumation, as Sydenham calls it, analogous in some measure to the intestine action by which fermenting liquors work the yest to the surface. The solids, on their part, when their action is obstructed, not only resume that action, as soon as the obstruction is removed, but they struggle with the impediment. They take an action as near to the true one, as the difficulty and the disorganization, with which they have to contend, will allow of.

Of *mortal* diseases, the great use is to reconcile us to death. The horror of death proves the value of life. But it is in the power of disease to abate, or even extinguish, this horror; which it does in a wonderful manner, and oftentimes by a mild and imperceptible gradation. Every man who has been placed in a situation to observe it, is surprised with the change which has been wrought in himself, when he compares the view which he entertains of death upon a sick-bed, with the heart-sinking dismay with which he should some time ago have met it in health. There is no

similitude between the sensations of a man led to execution, and the calm expiring of a patient at the close at his disease. Death to him is only the last of a long train of changes; in his progress through which, it is possible that he may experience no shocks or sudden transitions.

Death itself, as a mode of removal and of succession, is so connected with the whole order of our animal world, that almost every thing in that world must be changed, to be able to do without it. It may seem likewise impossible to separate the fear of death from the enjoyment of life, or the perception of that fear from rational natures. Brutes are, in a great measure, delivered from all anxiety on this account by the inferiority of their faculties; or rather, they seem to be armed with the apprehension of death just sufficiently to put them upon the means of preservation, and no farther. But would a human being wish to purchase this immunity, at the expense of those mental powers which enable him to look forward to the future?

Death implies *separation:* and the loss of those whom we love, must necessarily, so far as we can conceive, be accompanied with pain. To the brute creation, nature seems to have stepped in with some secret provision for their relief, under the rupture of their attachments. In their instincts towards their offspring, and of their offspring to them, I have often been surprised to observe how

ardently they love, and how soon they forget. The pertinacity of human sorrow (upon which, time also, at length lays its softening hand) is probably, therefore in some manner connected with the qualities of our rational or moral nature. One thing however is clear, viz. that it is better that we should possess affections, the sources of so many virtues, and so many joys, although they be exposed to the incidents of life, as well as the interruptions of mortality, than, by the want of them, be reduced to a state of selfishness, apathy, and quietism.

Of other external evils, (still confining ourselves to what are called physical or natural evils,) a considerable part come within the scope of the following observation:—The great principle of human satisfaction is *engagement.* It is a most just distinction, which the late Mr. Tucker has dwelt upon so largely in his works, between pleasures in which we are passive, and pleasures in which we are active. And, I believe, every attentive observer of human life will assent to his position, that however grateful the sensations may occasionally be in which we are passive, it is not these, but the latter class of our pleasures, which constitute satisfaction; which supply that regular stream of moderate and miscellaneous enjoyments, in which happiness, as distinguished from voluptuousness, consists. Now for rational occupation, which is, in other words, for the very material of

contented existence, there would be no place left, if either the things with which we had to do were absolutely impracticable to our endeavours, or if they were too obedient to our uses. A world, furnished with advantages on one side, and beset with difficulties, wants, and inconveniencies on the other, is the proper abode of free, rational, and active natures, being the fittest to stimulate and exercise their faculties. The very *refractoriness* of the objects they have to deal with, contributes to this purpose. A world in which nothing depended upon ourselves, however it might have suited an imaginary race of beings, would not have suited mankind. Their skill, prudence, industry; their various arts, and their best attainments, from the application of which they draw, if not their highest, their most permanent gratifications, would be insignificant, if things could be either moulded by our volitions, or, of their own accord, conformed themselves to our views and wishes. Now it is in this refractoriness that we discern the seed and principle of *physical* evil, as far as it arises from that which is external to us.

Civil evils, or the evils of civil life, are much more easily disposed of than physical evils; because they are, in truth, of much less magnitude, and also because they result, by a kind of necessity, not only from the constitution of our nature, but from a part of that constitution which

no one would wish to see altered. The case is this: mankind will in every country *breed up* to a certain point of distress. That point may be different in different countries or ages, according to the established usages of life in each. It will also shift upon the scale, so as to admit of a greater or less number of inhabitants, according as the quantity of provision, which is either produced in the country, or supplied to it from other countries, may happen to vary. But there must always be such a point, and the species will always breed up to it. The order of generation proceeds by something like a geometrical progression. The increase of provision under circumstances even the most advantageous, can only assume the form of an arithmetic series. Whence it follows, that the population will always overtake the provision, will pass beyond the line of plenty, and will continue to increase till checked by the difficulty of procuring subsistence.* Such difficulty therefore, along with its attendant circumstances, *must* be found in every old country: and these circumstances constitute what we call poverty, which necessarily imposes labour, servitude, restraint.

It seems impossible to people a country with inhabitants who shall be all easy in circumstances. For suppose the thing to be done, there would be such marrying and giving in marriage amongst

* See a statement of this subject, in a late treatise upon population.

them, as would in a few years change the face of affairs entirely; *i. e.* as would increase the consumption of those articles, which supplied the natural or habitual wants of the country, to such a degree of scarcity, as must leave the greatest part of the inhabitants unable to procure them without toilsome endeavours, or, out of the different kinds of these articles, to procure any kind except that which was most easily produced. And this, in fact, describes the condition of the mass of the community in all countries; a condition unavoidably, as it should seem, resulting from the provision which is made in the human, in common with all animal constitutions, for the perpetuity and multiplication of the species.

It need not however dishearten any endeavours for the public service, to know that population naturally treads upon the heels of improvement. If the condition of a people be meliorated, the consequence will be, either that the *mean* happiness will be increased, or a greater number partake of it; or, which is most likely to happen, that both effects will take place together. There may be limits fixed by nature to both, but they are limits, not yet attained, nor even approached, in any country of the world.

And when we speak of limits at all, we have respect only to provisions for animal wants. There are sources, and means, and auxiliaries, and augmentations of human happiness, communicable

without restriction of numbers; as capable of being possessed by a thousand persons as by one. Such are those which flow from a mild, contrasted with a tyrannic government, whether civil or domestic; those which spring from religion; those which grow out of a sense of security; those which depend upon habits of virtue, sobriety, moderation, order; those, lastly, which are found in the possession of well-directed tastes and desires, compared with the dominion of tormenting, pernicious, contradictory, unsatisfied, and unsatisfiable passions.

The *distinctions* of civil life are apt enough to be regarded as evils, by those who sit under them; but, in my opinion, with very little reason.

In the first place, the advantages which the higher conditions of life are supposed to confer, bear no proportion in value to the advantages which are bestowed by nature. The gifts of nature always surpass the gifts of fortune. How much, for example, is activity better than attendance; beauty than dress; appetite, digestion, and tranquil bowels, than all the studies of cookery, or than the most costly complication of forced, or far-fetched dainties!

Nature has a strong tendency to equalization. Habit, the instrument of nature, is a great leveller; the familiarity which it induces, taking off the edge both of our pleasures and our sufferings. Indulgencies which are habitual, keep us in ease,

and cannot be carried much farther. So that, with respect to the gratifications of which the senses are capable, the difference is by no means proportionable to the apparatus. Nay, so far as superfluity generates fastidiousness, the difference is on the wrong side.

It is not necessary to contend, that the advantages derived from wealth are none, (under due regulations they are certainly considerable,) but that they are not greater than they ought to be. *Money* is the sweetener of human toil; the substitute for coercion; the reconciler of labour with liberty. It is moreover, the stimulant of enterprise in all projects and undertakings, as well as of diligence in the most beneficial arts and employments. Now did affluence, when possessed, contribute nothing to happiness, or nothing beyond the mere supply of necessaries; and the secret should come to be discovered; we might be in danger of losing great part of the uses which are at present derived to us through this important medium. Not only would the tranquillity of social life be put in peril by the want of a motive to attach men to their private concerns; but the satisfaction which all men receive from success in their respective occupations, which collectively constitutes the great mass of human comfort, would be done away in its very principle.

With respect to *station*, as it is distinguished from riches, whether it confer authority over others,

or be invested with honours which apply solely to sentiment and imagination, the truth is, that what is gained by rising through the ranks of life, is not more than sufficient to draw forth the exertions of those who are engaged in the pursuits which lead to advancement, and which in general are such as ought to be encouraged. Distinctions of this sort are subjects much more of competition than of enjoyment: and in that competition their use consists. It is not, as hath been rightly observed, by what the *Lord Mayor* feels in his coach, but by what the *apprentice* feels who gazes at him, that the public is served.

As we approach the summits of human greatness, the comparison of good and evil, with respect to personal comfort, becomes still more problematical; even allowing to ambition all its pleasures. The poet asks, "what is grandeur, what is power?" The philosopher answers, "constraint and plague: *et in maxima quaque fortuna minimum licere.*" One very common error misleads the opinion of mankind on this head, viz. that universally, authority is pleasant, submission painful. In the general course of human affairs, the very reverse of this is nearer to the truth. Command is anxiety, obedience ease.

Artificial distinctions sometimes promote real equality. Whether they be hereditary, or be the homage paid to office, or the respect attached by public opinion to particular professions, they serve

to *confront* that grand and unavoidable distinction which arises from property, and which is most overbearing where there is no other. It is of the nature of property, not only to be irregularly distributed, but to run into large masses. Public laws should be so constructed as to favour its diffusion as much as they can. But all that can be done by laws consistently with that degree of government of his property which ought to be left to the subject, will not be sufficient to counteract this tendency. There must always therefore be the difference between rich and poor; and this difference will be the more grinding, when no pretension is allowed to be set up against it.

So that the evils, if evils they must be called, which spring either from the necessary subordinations of civil life, or from the distinctions which have, naturally, though not necessarily, grown up in most societies, so long as they are unaccompanied by privileges injurious or oppressive to the rest of the community, are such as may, even by the most depressed ranks, be endured with very little prejudice to their comfort.

The mischiefs of which mankind are the occasion to one another, by their private wickednesses, and cruelties; by tyrannical exercises of power; by rebellions against just authority; by wars, by national jealousies and competitions operating to the destruction of third countries; or by other instances of misconduct either in individuals or

societies, are all to be resolved into the character of man as a *free agent*. Free agency in its very essence contains liability to abuse. Yet, if you deprive man of his free agency, you subvert his nature. You may have order from him and regularity, as you may from the tides or the trade-winds, but you put an end to his moral character, to virtue, to merit, to accountableness, to the use indeed of reason. To which must be added the observation, that even the bad qualities of mankind have an origin in their good ones. The case is this: human passions are either necessary to human welfare, or capable of being made, and, in a great majority of instances, in fact made, conducive to its happiness. These passions are strong and general; and perhaps would not answer their purpose unless they were so. But strength and generality, when it is expedient that particular circumstances should be respected, become, if left to themselves, excess and misdirection. From which excess and misdirection, the vices of mankind (the causes no doubt of much misery) appear to spring. This account, whilst it shows us the principal of vice, shows us, at the same time the province of reason and of self-government; the want also of every support which can be procured to either from the aids of religion; and it shows this, without having recourse to any native gratuitous malignity in the human constitution. Mr. Hume, in his posthumous dialogues, asserts indeed

of *idleness*, or aversion to labour (which he states to lie at the root of a considerable part of the evils which mankind suffer,) that it is simply and merely bad. But how does he distinguish idleness from the love of ease? Or is he sure, that the love of ease in individuals is not the chief foundation of social tranquillity. It will be found, I believe, to be true, that in every community there is a large class of its members, whose idleness is the best quality about them, being the corrective of other bad ones. If it were possible, in every instance, to give a right determination to industry, we could never have too much of it. But this is not possible, if men are to be free. And without this, nothing would be so dangerous as an incessant, universal, indefatigable activity. In the civil world, as well as in the material, it is the *vis inertiæ* which keeps things in their places.

Natural Theology has ever been pressed with this question: why, under the regency of a supreme and benevolent Will, should there be, in the world, so much as there is of the appearance of *chance?*

The question in its whole compass lies beyond our reach: but there are not wanting, as in the origin of evil, answers which seem to have considerable weight in particular cases, and also to embrace a considerable number of cases.

I. There must be *chance* in the midst of design:

by which we mean, that events which are not designed, necessarily arise from the pursuit of events which are designed. One man travelling to York, meets another man travelling to London. Their meeting is by chance, is accidental, and so would be called and reckoned, though the journeys which produced the meeting were, both of them, undertaken with design and from deliberation. The meeting, though accidental, was nevertheless hypothetically necessary, (which is the only sort of necessity that is intelligible:) for, if the two journeys were commenced at the time, pursued in the direction, and with the speed, in which and with which they were in fact begun and performed, the meeting could not be avoided. There was not, therefore, the less necessity in it for its being by chance. Again, the rencounter might be most unfortunate, though the errands, upon which each party set out upon his journey, were the most innocent or the most laudable. The bye effect may be unfavourable, without impeachment of the proper purpose, for the sake of which the train, from the operation of which these consequences ensued, was put in motion. Although no cause acts without a good purpose; accidental consequences, like these, may be either good or bad.

II. The *appearance of chance* will always bear a proportion to the ignorance of the observer. The cast of a die as regularly follows the laws of motion, as the going of a watch; yet, because we

can trace the operation of those laws through the works and movements of the watch, and cannot trace them in the shaking and throwing of the die, (though the laws be the same, and prevail equally in both cases,) we call the turning up of the number of the die chance, the pointing of the index of the watch machinery, order, or by some name which excludes chance. It is the same in those events which depend upon the will of a free and rational agent. The verdict of a jury, the sentence of a judge, the resolution of an assembly, the issue of a contested election, will have more or less of the appearance of chance, might be more or less the subject of a wager, according as we were less or more acquainted with the reasons which influenced the deliberation. The difference resides in the information of the observer, and not in the thing itself; which, in all the cases proposed, proceeds from intelligence, from mind, from counsel, from design.

Now when this one cause of the appearance of chance, viz. the ignorance of the observer, comes to be applied to the operations of the Deity, it is easy to foresee how fruitful it must prove of difficulties, and of seeming confusion. It is only to think of the Deity, to perceive what variety of objects, what distance of time, what extent of space and action, his counsels may, or rather, must, comprehend. Can it be wondered at, that, of the purposes which dwell in such a

mind as this, so small a part should be known to us? It is only necessary, therefore, to bear in our thought, that in proportion to the inadequateness of our information, will be the quantity, in the world, of apparent chance.

III. In a great variety of cases, and of cases comprehending numerous subdivisions, it appears, for many reasons, to be better that events rise up by *chance*, or, more properly speaking, with the appearance of chance, than according to any observable rule whatever. This is not seldom the case even in human arrangements. Each person's place and precedency, in a public meeting may be determined by *lot*. Work and labour may be *allotted*. Tasks and burdens may be *allotted*:—

——Operumque laborem
Partibus æquabat justis, aut *sorte* trahebat.

Military service and station may be *allotted*. The distribution of provision may be made by *lot*, as it is in a sailor's mess; in some cases also, the distribution of favours may be made by *lot*. In all these cases, it seems to be acknowledged, that there are advantages in permitting events to chance, superior to those which would or could arise from regulation. In all these cases, also, though events rise up in the way of chance, it is by appointment that they do so.

In other events, and such as are independent of

human will, the reasons for this preference of uncertainty to rule, appear to be still stronger. For example, it seems to be expedient that the period of human life should be *uncertain*. Did mortality follow any fixed rule, it would produce a security in those that were at a distance from it, which would lead to the greatest disorders; and a horror in those who approached it, similar to that which a condemned prisoner feels on the night before his execution. But, that death be uncertain, the young must sometimes die, as well as the old. Also, were deaths never *sudden*, they who are in health would be too confident of life. The strong and the active, who want most to be warned and checked, would live without apprehension or restraint. On the other hand, were sudden deaths very frequent, the sense of constant jeopardy would interfere too much with the degree of ease and enjoyment intended for us; and human life be too precarious for the business and interests which belong to it. There could not be dependence either upon our own lives, or the lives of those with whom we are connected, sufficient to carry on the regular offices of human society. The manner, therefore, in which death is made to occur, conduces to the purposes of admonition, without overthrowing the necessary stability of human affairs.

Disease being the forerunner of death, there is the same reason for its attacks coming upon us

under the appearance of chance, as there is for uncertainty in the time of death itself.

The *seasons* are a mixture of regularity and chance. They are regular enough to authorize expectation, whilst their being in a considerable degree irregular, induces, on the part of the cultivators of the soil, a necessity for personal attendance, for activity, vigilance, precaution. It is this necessity which creates farmers; which divides the profit of the soil between the owner and the occupier; which, by requiring expedients, by increasing employment, and by rewarding expenditure, promotes agricultural arts and agricultural life, of all modes of life the best, being the most conducive to health, to virtue, to enjoyment. I believe it to be found in fact, that where the soil is the most fruitful, and the seasons the most constant, there the condition of the cultivators of the earth is the most depressed. Uncertainty, therefore, has its use, even to those who sometimes complain of it the most. Seasons of scarcity themselves are not without their advantages. They call forth new exertions; they set contrivance and ingenuity at work; they give birth to improvements in agriculture and economy; they promote the investigation and management of public resources.

Again; there are strong intelligible reasons, why there should exist in human society great disparity of *wealth* and *station;* not only as these

things are acquired in different degrees, but at the first setting out of life. In order, for instance, to answer the various demands of civil life, there ought to be amongst the members of every civil society a diversity of education, which can only belong to an original diversity of circumstances. As this sort of disparity, which ought to take place from the beginning of life, must, *ex hypothesi*, be previous to the merit or demerit of the persons upon whom it falls, can it be better disposed of than by chance? *Parentage* is that sort of chance: yet it is the commanding circumstance which in general fixes each man's place in civil life, along with every thing which appertains to its distinctions. It may be the result of a beneficial rule, that the fortunes or honours of the father devolve upon the son; and, as it should seem, of a still more necessary rule, that the low or laborious condition of the parent be communicated to his family; but with respect to the successor himself, it is the drawing of a ticket in a lottery. Inequalities therefore of fortune, at least the greatest part of them, viz. those which attend us from our birth, and depend upon our birth, may be left, as they are left, to *chance*, without any just cause for questioning the regency of a supreme Disposer of events.

But not only the donation, when by the necessity of the case they must be gifts, but even the *acquirability* of civil advantages, ought perhaps, in a considerable degree, to lie at the mercy of

chance. Some would have all the virtuous rich, or at least removed from the evils of poverty, without perceiving, I suppose, the consequence, that all the poor must be wicked. And how such a society could be kept in subjection to government, has not been shown: for the poor, that is, they who seek their subsistence by constant manual labour, must still form the mass of the community; otherwise the necessary labour of life could not be carried on; the work would not be done, which the wants of mankind, in a state of civilization, and still more in a state of refinement, require to be done.

It appears to be also true, that the exigencies of social life call not only for an original diversity of *external* circumstances, but for a mixture of different faculties, tastes, and tempers. Activity and contemplation, restlessness and quiet, courage and timidity, ambition and contentedness, not to say even indolence and dulness, are all wanted in the world, all conduce to the well going on of human affairs: just as the rudder, the sails, and the ballast of a ship, all perform their part in the navigation. Now, since these characters require for their foundation different original talents, different dispositions, perhaps also different bodily constitutions: and since, likewise, it is apparently expedient, that they be promiscuously scattered amongst the different classes of society; can the distribution of talents, dispositions, and the constitutions

upon which they depend, be better made than by *chance?*

The *opposites* of apparent chance are, constancy and sensible interposition; every degree of *secret* direction being consistent with it. Now, of *constancy*, or of fixed and known rules, we have seen in some cases the inapplicability; and inconveniencies which we do not see, might attend their application in other cases.

Of *sensible* interposition we may be permitted to remark, that a Providence, always and certainly distinguishable, would be neither more nor less than miracles rendered frequent and common. It is difficult to judge of the state into which this would throw us. It is enough to say, that it would cast us upon a quite different dispensation from that under which we live. It would be a total and radical change. And the change would deeply affect, or perhaps subvert, the whole conduct of human affairs. I can readily believe, that other circumstances being adapted to it, such a state might be better than our present state. It may be the state of other beings; it may be ours hereafter. But the question with which we are now concerned is, how far it would be consistent with our condition, supposing it in other respects to remain as it is? And in this question there seem to be reasons of great moment on the negative side. For instance; so long as bodily labour continues, on so many accounts, to be ne-

cessary for the bulk of mankind, any dependency upon a supernatural aid, by unfixing those motives which promote exertion, or by relaxing those habits which engender patient industry, might introduce negligence, inactivity, and disorder, into the most useful occupations of human life; and thereby deteriorate the condition of human life itself.

As moral agents, we shonld experience a still greater alteration; of which, more will be said under the next article.

Although therefore the Deity, who possesses the power of winding and turning, as he pleases, the course of causes which issue from himself, do in fact interpose to alter or intercept effects, which without such interposition would have taken place; yet it is by no means incredible, that his Providence, which always rests upon final good, may have made a *reserve* with respect to the manifestation of his interference, a part of the very plan which he has appointed for our terrestrial existence, and a part conformable with, or in some sort required by, other parts of the same plan. It is at any rate evident, that a large and ample province remains for the exercise of Providence, without its being naturally perceptible by us; because obscurity, when applied to the interruption of laws, bears a necessary proportion to the imperfection of our knowledge when applied to the laws themselves, or rather to the effects which these laws,

under their various and incalculable combinations, would of their own accord produce. And if it be said, that the doctrine of Divine Providence, by reason of the ambiguity under which its exertions present themselves, can be attended with no *practical* influence upon our conduct; that, although we believe ever so firmly that there is a Providence, we must prepare, and provide, and act, as if there were none; I answer, that this is admitted; and that we further allege, that so to prepare, and so to provide, is consistent with the most perfect assurance of the reality of a Providence: and not only so, but that it is probably one advantage of the present state of our information, that our provisions and preparations are not disturbed by it. Or if it be still asked, of what use at all then is the doctrine, if it neither alter our measures nor regulate our conduct? I answer again, that it is of the greatest use, but that it is a doctrine of sentiment and piety, not (immediately at least) of action or conduct; that it applies to the consolation of men's minds, to their devotions, to the excitement of gratitude, the support of patience, the keeping alive and the strengthening of every motive for endeavouring to please our Maker; and that these are great uses.

Of all views under which human life has ever been considered, the most reasonable, in my judgment, is that which regards it as a state of *probation*. If the course of the world was separated

from the contrivances of nature, I do not know that it would be necessary to look for any other account of it than what, if it may be called an account, is contained in the answer, that events rise up by chance. But since the contrivances of nature decidedly evince *intention;* and since the course of the world and the contrivances of nature have the same author; we are, by the force of this connexion, led to believe, that the appearance under which events take place, is reconcileable with the supposition of design on the part of the Deity. It is enough that they be reconcileable with this supposition; and it is undoubtedly true, that they may be reconcileable, though we cannot reconcile them. The mind, however, which contemplates the works of Nature, and in those works sees so much of means directed to ends, of beneficial effects brought about by wise expedients, of concerted trains of causes terminating in the happiest results; so much, in a word, of counsel, intention, and benevolence; a mind, I say, drawn into the habit of thought which these observations excite, can hardly turn its view to the condition of our own species, without endeavouring to suggest to itself some purpose, some design, for which the state in which we are placed is fitted, and which it is made to serve. Now we assert the most probable supposition to be, that it is a state of moral probation; and that many things in it suit with this hypothesis, which suit no other. It is not a state of un-

mixed happiness, or of happiness simply : it is not a state of designed misery, or of misery simply: it is not a state of retribution : it is not a state of punishment. It suits with none of these suppositions. It accords much better with the idea of its being a condition calculated for the production, exercise, and improvement of moral qualities, with a view to a future state, in which these qualities, after being so produced, exercised, and improved, may, by a new and more favouring constitution of things, receive their reward, or become their own. If it be said, that this is to enter upon a religious rather than a philosophical consideration, I answer, that the name of Religion ought to form no objection, if it shall turn out to be the case, that the more religious our views are, the more probability they contain. The degree of beneficence, of benevolent intention, and of power, exercised in the construction of sensitive beings, goes strongly in favour, not only of a creative, but of a continuing care, that is, of a ruling Providence. The degree of chance which appears to prevail in the world, requires to be reconciled with this hypothesis. Now it is one thing to maintain the doctrine of Providence along with that of a future state, and another thing without it. In my opinion, the two doctrines must stand or fall together. For although more of this apparent chance may perhaps, upon other principles, be accounted for, than is generally supposed, yet a future state alone rectifies all

disorders: and if it can be shown, that the appearance of disorder is consistent with the uses of life as a *preparatory* state, or that in some respects it promotes these uses, then, so far as this hypothesis may be accepted, the ground of the difficulty is done away.

In the wide scale of human condition, there is not perhaps one of its manifold diversities which does not bear upon the design here suggested. Virtue is infinitely various. There is no situation in which a rational being is placed, from that of the best instructed Christian down to the condition of the rudest barbarian, which affords not room for moral agency; for the acquisition, exercise, and display of voluntary qualities, good and bad. Health and sickness, enjoyment and suffering, riches and poverty, knowledge and ignorance, power and subjection, liberty and bondage, civilization and barbarity, have all their offices and duties, all serve for the *formation* of character: for when we speak of a state of trial, it must be remembered, that characters are not only tried, or proved, or detected, but that they are generated also, and *formed* by circumstances. The best dispositions may subsist under the most depressed, the most afflicted fortunes. A West Indian slave, who, amidst his wrongs, retains his benevolence, I, for my part, look upon as amongst the foremost of human candidates for the rewards of virtue. The kind master of such a slave, that is, he who,

in the exercise of an inordinate authority, postpones in any degree his own interest to his slave's comfort, is likewise a meritorious character: but still he is inferior to his slave. All however which I contend for is, that these destinies, opposite as they may be in every other view, are both *trials;* and equally such. The observation may be applied to every other condition; to the whole range of the scale, not excepting even its lowest extremity. *Savages* appear to us all alike; but it is owing to the distance at which we view savage life, that we perceive in it no discrimination of character. I make no doubt, but that moral qualities, both good and bad, are called into action as much, and that they subsist in as great variety in these inartificial societies, as they are, or do, in polished life. Certain at least it is, that the good and ill treatment which each individual meets with, depends more upon the choice and voluntary conduct of those about him, than it does, or ought to do, under regular civil institutions, and the coercion of public laws. So again, to turn our eyes to the other end of the scale, namely, that part of it which is occupied by mankind enjoying the benefits of learning, together with the lights of revelation, there also, the advantage is all along *probationary.* Christianity itself, I mean the revelation of Christianity, is not only a blessing, but a trial. It is one of the diversified means by which the character is exer-

cised: and they who require of Christianity, that the revelation of it should be universal, may possibly be found to require, that one species of probation should be adopted, if not to the exclusion of others, at least to the narowing of that variety which the wisdom of the Deity hath appointed to this part of his moral economy.*

Now if this supposition be well founded; that is, if it be true that our ultimate, or our most permanent happiness will depend, not upon the temporary condition into which we are cast, but upon our behaviour in it; then is it a much more fit subject of *chance* than we usually allow or apprehend it to be, in what manner the variety of external circumstances which subsist in the human world, is distributed amongst the individuals of the species. "This life being a state of probation, it is immaterial," says Rousseau, "what kind of trials we experience in it, provided they produce their effects." Of two agents who stand indifferent to the moral Governor of the universe, one may be exercised by riches, the other by poverty. The treatment of these two shall appear

* The reader will observe, that I speak of the revelation of Christianity as distinct from Christianity itself. The *dispensation* may already be universal. That part of mankind which never heard of Christ's name, may nevertheless be redeemed; that is, be placed in a better condition, with respect to their future state, by his intervention; may be the objects of his benignity and intercession, as well as of the propitiatory virtue of his passion. But this is not "Natural Theology;" therefore I will not dwell longer upon it.

to be very opposite, whilst in truth it is the same: for though, in many respects, there be great disparity between the conditions assigned, in one main article there may be none, viz. in that they are alike trials; have both their duties and temptations, not less arduous or less dangerous in one case than the other; so that if the final award follow the character, the original distribution of the circumstances under which that character is formed, may be defended upon principles not only of justice but of equality. What hinders, therefore, but that mankind may draw lots for their condition. They take their portion of faculties and opportunities, as any unknown cause, or concourse of causes, or as causes acting for other purposes, may happen to set them out: but the event is governed by that which depends upon themselves, the application of what they have received. In dividing the talents, no rule was observed; none was necessary: in rewarding the use of them, that of the most correct justice. The chief difference at last appears to be, that the right use of more talents, *i. e.* of a greater trust, will be more highly rewarded, than the right use of fewer talents, *i. e.* of a less trust. And since, for other purposes, it is expedient that there be an inequality of concredited talents here, as well, probably, as an equality of conditions hereafter, though all remuneratory; can any rule, adapted to that inequality, be more agreeable, even to

our apprehensions of distributive justice than this is?

We have said that the appearance of *casualty*, which attends the occurrences and events of life, not only does not interfere with its uses, as a state of probation, but that it promotes these uses.

Passive virtues, of all others the severest and the most sublime; of all others, perhaps, the most acceptable to the Deity; would, it is evident, be excluded from a constitution, in which happiness and misery regularly followed virtue and vice. Patience and composure under distress, affliction, and pain; a steadfast keeping up of our confidence in God, and of our reliance upon his final goodness, at the time when every thing present is adverse and discouraging; and (what is no less difficult to retain) a cordial desire for the happiness of others, even when we are deprived of our own: these dispositions, which constitute, perhaps, the perfection of our moral nature, would not have found their proper office and object in a state of avowed retribution; and in which, consequently, endurance of evil would be only submission to punishment.

Again: one man's sufferings may be another man's trial. The family of a sick parent is a school of filial piety. The charities of domestic life, and not only these, but all the social virtues, are called out by distress. But then, misery, to be the proper object of mitigation, or of that be-

nevolence which endeavours to relieve, must be really or apparently casual. It is upon such sufferings alone that benevolence can operate. For were there no evils in the world, but what were punishments, properly and intelligibly such, benevolence would only stand in the way of justice. Such evils, consistently with the administration of moral government, could not be prevented or alleviated, that is to say, could not be remitted in whole or in part, except by the authority which inflicted them, or by an appellate or superior authority. This consideration, which is founded in our most acknowledged apprehensions of the nature of penal justice, may possess its weight in the Divine counsels. Virtue perhaps is the greatest of all ends. In human beings, relative virtues form a large part of the whole. Now relative virtues presupposes, not only the existence of evil, without which it could have no object, no material to work upon, but that evils be, apparently at least, *misfortunes;* that is, the effects of apparent chance. It may be in pursuance, therefore, and in furtherance of the same scheme of probation, that the evils of life are made *so* to present themselves.

I have already observed, that, when we let in religious considerations, we often let in light upon the difficulties of nature. So in the fact now to be accounted for, the *degree* of happiness which we usually enjoy in this life, may be better suited

to a state of trial and probation, than a greater degree would be. The truth is, we are rather too much delighted with the world, than too little. Imperfect, broken, and precarious as our pleasures are, they are more than sufficient to attach us to the eager pursuit of them. A regard to a *future* state can hardly keep its place as it is. If we were designed, therefore, to be influenced by that regard, might not a more indulgent system, a higher, or more uninterrupted state of gratification, have interfered with the design? At least it seems expedient, that mankind should be susceptible of this influence, when presented to them: that the condition of the world should not be such as to exclude its operation, or even to weaken it more than it does. In a religious view (however we may complain of them in every other,) privation, disappointment, and satiety, are not without the most salutary tendencies.

CHAPTER XXVII.

CONCLUSION.

In all cases, wherein the mind feels itself in danger of being confounded by variety, it is sure to rest upon a few strong points, or perhaps upon a single

instance. Amongst a multitude of proofs, it is *one* that does the business. If we observe in any argument, that hardly two minds fix upon the same instance, the diversity of choice shows the strength of the argument, because it shows the number and competition of the examples. There is no subject in which the tendency to dwell upon select or single topics is so usual, because there is no subject, of which, in its full extent, the latitude is so great, as that of natural history applied to the proof of an intelligent Creator. For my part, I take my stand in human anatomy; and the examples of mechanism I should be apt to draw out from the copious catalogue which it supplies, are the pivot upon which the head turns, the ligament within the socket of the hip-joint, the pulley or trochlear muscles of the eye, the epiglottis, the bandages which tie down the tendons of the wrist and instep, the slit or perforated muscles at the hands and feet, the knitting of the intestines to the mesentery, the course of the chyle into the blood, and the constitution of the sexes as extended throughout the whole of the animal creation. To these instances the reader's memory will go back, as they are severally set forth in their places; there is not one of the number which I do not think decisive; not one which is not strictly mechanical; nor have I read or heard of any solution of these appearances, which, in the

smallest degree, shakes the conclusion that we build upon them.

But, of the greatest part of those, who, either in this book or any other, read arguments to prove the existence of a God, it will be said, that they leave off only where they began; that they were never ignorant of this great truth, never doubted of it; that it does not, therefore, appear what is gained by researches from which no new opinion is learned, and upon the subject of which no proofs were wanted. Now I answer, that, by *investigation*, the following points are always gained, in favour of doctrines even the most generally acknowledged, (supposing them to be true,) viz. stability and impression. Occasions will arise to try the firmness of our most habitual opinions. And upon these occasions, it is a matter of incalculable use to feel our foundation; to find a support in argument for what we had taken up upon authority. In the present case, the arguments upon which the conclusion rests, are exactly such as a truth of universal concern ought to rest upon. "They are sufficiently open to the views and capacities of the unlearned, at the same time that they acquire new strength and lustre from the discoveries of the learned." If they had been altogether abstruse and recondite, they would not have found their way to the understandings of the mass of mankind; if they had been merely popular, they might have wanted solidity.

But, secondly, what is gained by research in the stability of our conclusion, is also gained from it in *impression*. Physicians tell us, that there is a great deal of difference between taking a medicine, and the medicine getting into the constitution. A difference not unlike which, obtains with respect to those great moral propositions, which ought to form the directing principles of human conduct. It is one thing to assent to a proposition of this sort; and another, and a very different thing, to have properly imbibed its influence. I take the case to be this: perhaps almost every man living has a peculiar train of thought, into which his mind glides and falls, when at leisure from the impressions and ideas that occasionally excite it; perhaps, also, the train of thought here spoken of, more than any other thing, determines the character. It is of the utmost consequence, therefore, that this property of our constitution be well regulated. Now it is by frequent or continued meditation upon a subject, by placing a subject in different points of view, by induction of particulars, by variety of examples, by applying principles to the solution of phenomena, by dwelling upon proofs and consequences, that mental exercise is drawn into any particular channel. It is by these means, at least, that we have any power over it. The train of spontaneous thought, and the choice of that train, may be directed to different ends, and may appear to be more or less ju-

diciously fixed, according to the purpose in respect of which we consider it: but in a *moral view*, I shall not, I believe, be contradicted, when I say, that, if one train of thinking be more desirable than another, it is that which regards the phenomena of nature with a constant reference to a supreme intelligent Author. To have made this the ruling, the habitual sentiment of our minds, is to have laid the foundation of every thing which is religious. The world thenceforth becomes a temple, and life itself one continued act of adoration. The change is no less than this; that whereas formerly God was seldom in our thoughts, we can now scarcely look upon any thing without perceiving its relation to him. Every organized natural body, in the provisions which it contains for its sustentation and propagation, testifies a care, on the part of the Creator, expressly directed to these purposes. We are on all sides surrounded by such bodies; examined in their parts, wonderfully curious; compared with one another, no less wonderfully diversified. So that the mind, as well as the eye, may either expatiate in variety and multitude, or fix itself down to the investigation of particular divisions of the science. And in either case it will rise up from its occupation, possessed by the subject, in a very different manner, and with a very different degree of influence, from what a mere assent to any verbal proposition which can be formed concerning the existence of

the Deity, at least that merely complying assent with which those about us are satisfied, and with which we are too apt to satisfy ourselves, will or can produce upon the thoughts. More especially may this difference be perceived, in the degree of admiration and of awe with which the Divinity is regarded, when represented to the understanding by its own remarks, its own reflections, and its own reasonings, compared with what is excited by any language that can be used by others. The works of nature want only to be contemplated. When contemplated, they have every thing in them which can astonish by their greatness: for, of the vast scale of operation through which our discoveries carry us, at one end we see an intelligent Power arranging planetary systems, fixing, for instance, the trajectory of *Saturn*, or constructing a ring of two hundred thousand miles diameter to surround his body, and be suspended like a magnificent arch over the heads of his inhabitants; and, at the other, bending a hooked tooth, concerting and providing an appropriate mechanism, for the clasping and reclasping of the filaments of the feather of the humming-bird. We have proof, not only of both these works proceeding from an intelligent agent, but of their proceeding from the same agent: for, in the first place, we can trace an identity of plan, a connexion of system, from Saturn to our own globe: and when arrived upon our globe, we can, in the second

place, pursue the connexion through all the organized, especially the animated, bodies which it supports. We can observe marks of a common relation, as well to one another, as to the elements of which their habitation is composed. Therefore one mind hath planned, or at least hath prescribed, a general plan for all these productions. One Being has been concerned in all.

Under this stupendous Being we live. Our happiness, our existence, is in his hands. All we expect must come from him. Nor ought we to feel our situation insecure. In every nature, and in every portion of nature, which we can descry, we find attention bestowed upon even the minutest parts. The hinges in the wings of an *earwig*, and the joints of its antennæ, are as highly wrought, as if the Creator had nothing else to finish. We see no signs of diminution of care by multiplicity of objects, or of distraction of thought by variety. We have no reason to fear, therefore, our being forgotten, or overlooked, or neglected.

The existence and character of the Deity, is, in every view, the most interesting of all human speculations. In none, however, is it more so, than as it facilitates the belief of the fundamental articles of *Revelation*. It is a step to have it proved, that there must be something in the world more than what we see. It is a farther step to know, that amongst the invisible things of nature, there must be an intelligent mind, concerned in its pro-

duction, order, and support. These points being assured to us by Natural Theology, we may well leave to Revelation the disclosure of many particulars, which our researches cannot reach, respecting either the nature of this Being as the original cause of all things, or his character and designs as a moral governor; and not only so, but the more full confirmation of other particulars, of which, though they do not lie altogether beyond our reasonings and our probabilities, the certainty is by no means equal to the importance. The true theist will be the first to listen to *any* credible communication of Divine knowledge. Nothing which he has learned from Natural Theology, will diminish his desire of farther instruction, or his disposition to receive it with humility and thankfulness. He wishes for light: he rejoices in light. His inward veneration of this great Being, will incline him to attend with the utmost seriousness, not only to all that can be discovered concerning him by researches into nature, but to all that is taught by a revelation, which gives reasonable proof of having proceeded from him.

But above every other article of revealed religion, does the anterior belief of a Deity bear with the strongest force upon that grand point, which gives indeed interest and importance to all the rest—the resurrection of the human dead. The thing might appear hopeless, did we not see a power at work adequate to the effect, a power

under the guidance of an intelligent will, and a power penetrating the inmost recesses of all substance. I am far from justifying the opinion of those, who "thought it a thing incredible that God should raise the dead:" but I admit, that it is first necessary to be persuaded, that there *is* a God to do so. This being thoroughly settled in our minds, there seems to be nothing in this process (concealed as we confess it to be) which need to shock our belief. They who have taken up the opinion, that the acts of the human mind depend upon *organization*, that the mind itself indeed consists in organization, are supposed to find a greater difficulty than others do, in admitting a transition by death to a new state of sentient existence, because the old organization is apparently dissolved. But I do not see that any impracticability need be apprehended even by these; or that the change, even upon their hypothesis, is far removed from the analogy of some other operations, which we know with certainty that the Deity is carrying on. In the ordinary derivation of plants and animals from one another, a particle, in many cases, minuter than all assignable, all conceivable dimension; an aura, an effluvium, an infinitesimal; determines the organization of a future body; does no less than fix, whether that which is about to be produced shall be a vegetable, a merely sentient, or a rational being; an oak, a frog, or a philosopher; makes all these differences; gives to the

future body its qualities, and nature, and species. And this particle, from which springs, and by which is determined a whole future nature, itself proceeds from, and owes its constitution to, a prior body; nevertheless, which is seen in plants most decisively, the incepted organization, though formed within, and through, and by a preceding organization, is not corrupted by its corruption, or destroyed by its dissolution; but, on the contrary, is sometimes extricated and developed by those very causes; survives and comes into action, when the purpose for which it was prepared requires its use. Now an economy which nature has adopted, when the purpose was to transfer an organization from one individual to another, may have something analogous to it, when the purpose is to transmit an organization from one state of being to another state: and they who found thought in organization, may see something in this analogy applicable to their difficulties; for whatever can transmit a similarity of organization will answer their purpose, because, according even to their own theory, it may be the vehicle of consciousness; and because consciousness carries indentity and individuality along with it through all changes of form or of visible qualities. In the most general case, that, as we have said, of the derivation of plants and animals from one another, the latent organization is either itself similar to the old organization, or has the power of communicating to

new matter the old organic form. But it is not restricted to this rule. There are other cases, especially in the progress of insect life, in which the dormant organization does not much resemble that which encloses it, and still less suits with the situation in which the enclosing body is placed, but suits with a different situation to which it is destined. In the larva of the libellula, which lives constantly, and has still long to live, under water, are descried the wings of a fly, which two years afterwards is to mount into the air. Is there nothing in this analogy ?—It serves at least to show, that even in the observable course of nature, organizations are formed one beneath another; and, amongst a thousand other instances, it shows completely, that the Deity can mould and fashion the parts of material nature, so as to fulfil any purpose whatever which he is pleased to appoint.

They who refer the operations of mind to a substance totally and essentially different from matter, (as most certainly these operations, though affected by material causes, hold very little affinity to any properties of matter with which we are acquainted,) adopt perhaps a juster reasoning and a better philosophy; and by these the considerations above suggested are not wanted, at least in the same degree. But to such as find, which some persons do find, an insuperable difficulty in shaking off an adherence to those analogies which the corporeal world is continually suggesting to their

thoughts; to such I say, every consideration will be a relief, which manifests the extent of that intelligent power which is acting in nature, the fruitfulness of its resources, the variety, and aptness, and success of its means; most especially every consideration which tends to show, that, in the translation of a conscious existence, there is not, even in their own way of regarding it, any thing greatly beyond, or totally unlike, what takes place in such parts (probably small parts) of the order of nature, as are accessible to our observation.

Again; if there be those who think, that the contractedness and debility of the human faculties in our present state seem ill to accord with the high destinies which the expectations of religion point out to us, I would only ask them, whether any one, who saw a child two hours after its birth, could suppose that it would ever come to understand *fluxions?** or who then shall say, what farther amplification of intellectual powers, what accession of knowledge, what advance and improvement, the rational faculty, be its constitution what it will, may not admit of, when placed amidst new objects, and endowed with a sensorium adapted, as it undoubtedly will be, and as our present senses are, to the perception of those substances, and of those properties of things, with which our concern may lie.

* See Search's Light of Nature, passim.

Upon the whole; in every thing which respects this awful, but, as we trust, glorious change, we have a wise and powerful Being (the author, in nature, of infinitely various expedients, for infinitely various ends) upon whom to rely for the choice and appointment of means, adequate to the execution of any plan which his goodness or his justice may have formed, for the moral and accountable part of his terrestrial creation. That great office rests with *him:* be it *ours* to hope and to prepare, under a firm and settled persuasion, that, living and dying, we are his; that life is passed in his constant presence, that death resigns us to his merciful disposal.

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